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EIGHTH-GRADE EARTH SCIENCE. TEXTBOOK READABILITY AND OTHER FACTORS WHICH COULD INFLUENCE THE SUCCESS OF THE EIGHTH-GRADE EARTH SCIENCE COURSE IN THE TEXAS PUBLIC SCHOOLS.

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THE PURPOSE OF THIS STUDY WAS (1) TO DETERMINE THE READING DIFFICULTY OF THE EIGHTH-GRADE SCIENCE TEXTBOOKS ADOPTED FOR USE IN TEXAS PUBLIC SCHOOLS AND (2) TO DETERMINE THE ADEQUACY OF TEACHER PREPARATION, EQUIPMENT, AND SCHOOL FACILITIES FOR PRESENTING A COURSE IN EARTH SCIENCE BASED UPON THE TEXTBOOKS ADOPTED IN 1964. DATA FOR THE READABILITY STUDY INCLUDED DIFFICULTY DETERMINATIONS OBTAINED THROUGH USE OF THE DALE-CHALL FORMULA. DATA CONCERNING TEACHER PREPARATION AND EQUIPMENT FOR TEACHING EARTH SCIENCE WERE OBTAINED THROUGH THE USE OF QUESTIONNAIRES FROM 491 PARTICIPATING JUNIOR HIGH SCHOOL AND ELEMENTARY TEACHERS. THE WRITER FELT THAT NONE OF THE EARTH SCIENCE TEXTBOOKS EXAMINED IN THE STUDY WERE FOUND SUITABLE FOR EIGHTH-GRADE SCIENCE CLASSES. OF THE 491 TEACHERS RESPONDING TO THE QUESTIONNAIRE, ONLY 4.5 PERCENT MET THE MINIMUM STANDARDS OF ACADEMIC PREPARATION SUGGESTED BY THE EARTH SCIENCE CURRICULUM PROJECT. MOST SCHOOLS HAD LESS THAN 50 PERCENT OF THE EARTH SCIENCE EQUIPMENT SUGGESTED IN THE ADOPTED TEXTBOOKS. (AG)

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EIGHTH-GRADE EARTH SCIENCE

(Textbook Readability and Other Factors which
Could Influence the Success of the
Eighth-Grade, Earth Science Course
in the Texas Public Schools)

a dissertation
by

Loren E. Kline Jr.

East Texas State University
Department of Earth Science

AUG 2 5 1966

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TEXTBOOK READABILITY AND OTHER FACTORS WHICH COULD INFLUENCE THE SUCCESS OF THE EIGHTH-GRADE, EARTH SCIENCE COURSE IN THE TEXAS PUBLIC SCHOOLS

by

Loren E. Kline, Jr.

Submitted to the Faculty of the Graduate School of
East Texas State University
in partial fulfillment of the requirements
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August, 1966

TEXTBOOK READABILITY AND OTHER FACTORS WHICH COULD INFLUENCE THE SUCCESS OF THE EIGHTH-GRADE, EARTH SCIENCE COURSE IN THE TEXAS PUBLIC SCHOOLS

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ABSTRACT

TEXTBOOK READABILITY AND OTHER FACTORS WHICH COULD INFLUENCE THE SUCCESS OF THE EIGHTH-GRADE, EARTH SCIENCE COURSE IN THE TEXAS PUBLIC SCHOOLS

Loren E. Kline, Jr., Ph. D.
East Texas State University, 1966

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PURPOSE

The purpose of this study was twofold: (1) to determine the reading difficulty of the textbooks adopted for use in the eighth-grade science classes of the public schools of Texas; and (2) to determine how well the teachers were prepared and how well the schools were equipped to present a course in earth science based upon textbooks adopted in 1964.

METHOD OF STUDY

The reading difficulty of the textbooks was determined by means of the Dale-Chall formula for predicting readability.

Teacher preparation and equipment requirements of the Texas public schools were determined by means of questionnaires sent to 252 of the 254 counties in Texas. The data concerning

the preparation of the teachers were compiled up to and including the end of the spring semester of the 1964-65 academic year. The material requirements necessary for the teaching of earth science in the Texas public schools were determined by means of a systematic study of the three textbooks adopted by the state in November, 1964.

RESULTS

Texas has adopted three earth science and two general science textbooks for use in eighth-grade science classes.

Basic Earth Science by MacCracken and others and Earth Science: The World We Live In by Namowitz and Stone, two of the state adopted earth science texts, have a measured reading level of ninth-tenth-grade. Modern Earth Science by Ramsey and Burckley, the third earth science text, has a measured reading level of eleventh-twelfth-grade. A new earth science textbook, not on the adoption list, Exploring Earth Science by Thurber and Kilburn, also has a ninth-tenth-grade reading level.

One of the general science textbooks adopted for use in the eighth-grade, Modern Science 2 by Blanc and others, has a measured reading level of eleventh-twelfth-grade. The other general science textbook, Science is Understanding by Beauchamp and others, has a measured reading level of seventh-eighth-grade.

Of the 491 teachers who responded to the questionnaire, only 4.5 per cent met the minimum standards of academic preparation suggested by the Earth Science Curriculum Project. Of the 491 teachers, 86 per cent had taken no courses in astronomy and 98 per cent had taken two or less courses; in geology, 64 per cent reported no courses taken and 91 per cent reported two courses or less; in meteorology, 87 per cent reported no courses and 99 per cent two courses or less; in mineralogy, 89 per cent reported no courses and 98 per cent two courses or less; in oceanography, 94 per cent reported no courses and 99 per cent two courses or less; in paleontology, 90 per cent with no courses and 98 per cent two courses or less; in earth science, 58 per cent of teachers reported that they had taken no courses in this subject matter area and 70 per cent reported that they had taken two courses or less.

The equipment status of Texas schools is somewhat better. The schools are moderately well equipped to present biology, chemistry, and physics. For earth science, however, the schools average less than half of the equipment that they need.

RECOMMENDATIONS

(1). Textbooks for all subject matter areas should be written at a reading level in keeping with the grade in which the book will be used. This is particularly true for the textbooks of the various scientific disciplines. Greater attention should be paid by the authors to vocabulary load.

(2). Superintendents of schools should have a more intimate knowledge of the content of the courses taught in their schools. This knowledge is necessary in order that they are better prepared to hire teachers best qualified to offer the subject matter presented by the schools under their supervision.

(3). Departments of Geology or Earth Science must give more attention to the preparation of earth science teachers. It is anticipated that in the near future the need for teachers of earth science will far exceed the need for professional earth scientists.

(4) Schools and Colleges of Education should offer programs which will prepare teachers of earth science and should move in the direction of a teaching certificate and programs for such a certificate in the field of earth science.

(5). More summer programs are needed to up-grade the teachers of earth science, particularly those with long periods of professional experience.

(6). Superintendents, supervisors of instruction, and curriculum directors should check the equipment status of their schools against lists of equipment. These lists should be prepared from the items of equipment used or described by the authors of the textbooks used in their schools. Efforts should be directed toward bringing the equipment inventories up to the levels required for effective instruction from the textbooks in use in the classrooms.

(7). Advantage should be taken of both the federal and private foundation funds for the up-grading of the teachers through in-service programs. Such funds should also be used to bring equipment inventories up to at least the minimum standards suggested by the authors of the textbooks used in the schools.

(8). Better salaries should be paid to the teachers in order to reduce the serious shortage of earth science teachers.

ACKNOWLEDGMENTS

The successful completion of this study is the result of the patience and efforts of many people. The author would like to express his appreciation to the members of the graduate committee whose help contributed in a large measure to the success of this research. To Dr. Grady G. Tice, Dr. Roy N. Jervis, Dr. J. Webb Jones, Dr. Ronald W. Wheeler, Jr., Dr. Everett Erb and Dean William E. Truax, Jr. go the author's special thanks.

Appreciation is expressed to the textbook companies who supplied the textbooks analyzed in this study.

Gratitude is also expressed to Loren E. Kline, father of the author, whose encouragement contributed much to the completion of this work.

This dissertation is dedicated to the author's wife, Eleanor, and children, Loren William and Martha Louise, whose faith, sacrifices, encouragement, and help made this work possible.

TABLE OF CONTENTS

Page

ABSTRACT i

ACKNOWLEDGMENTS vi

LIST OF TABLES ix

LIST OF ILLUSTRATIONS x

Chapter

I. INTRODUCTION 1

Statement of the Problem
Method of Study
Limitations
Historical Background
Significance of this Study
Definition of Terms

II. REVIEW OF RELATED LITERATURE 30

Readability
  Historical Background
  Science Books
  Illustration of Readability Formulas
  Selection of a Formula
  Textbook Selection
  Summary
Survey of Texas Schools and Teachers
  Teacher Preparation
  General Science or Earth Science and Course Content
  National Curriculum Projects
    Statewide Curriculum Studies
    Earth Science Curriculum Project

III. PROCEDURE 155

Readability Determinations
Teacher Preparation and Equipment Status of Texas Schools
  Method Sampling
  Preparation of the Questionnaire
  Treatment of the Data

Chapter Page

IV. FINDING AND RESULTS 172

Readability Determinations
Teacher Preparation and Equipment Status of Texas schools
Teacher Preparation
Equipment and its Availability to the Teachers

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS . . 217

Summary and Conclusions
Readability Determinations
Teacher Preparation and Equipment Status of Texas Schools
Recommendations
Readability Determinations
Teacher Preparation and Equipment Status of Texas Schools

APPENDIX A 223

APPENDIX B 233

BIBLIOGRAPHY 238

VITA 259

LIST OF TABLES

Table | Page

1. Namowitz and Stone Earth Science: The World We Live In, Number of Copies Sold from Date of Adoption to the Present 13

2. Meaning of Reading Ease Score 108

3. Correction Table 111

4. Sample Work Sheet for the Dale-Chall Formula. . 161

5. Sample Work Sheet for the Dale-Chall Formula. . 163

6. The Extremes and Average Readability Scores of the Seven Textbooks Analyzed 175

7. The Extremes and Average Sentence Lengths of the Seven Textbooks Examined 176

8. Distribution of Teachers by the Number of Courses They Have Taken in Specified Disciplines 192

9. Schools Reporting Ownership of Geology and Mineralogy Equipment 203

10. Schools Reporting the Ownership of Paleontology Equipment 205

11. Schools Reporting the Ownership of Astronomy and Meteorology Equipment 206

12. Schools Reporting the Ownership of Biology Equipment 207

13. Schools Reporting the Ownership of Chemistry Equipment 208

14. Schools Reporting the Ownership of Physics Equipment 210

15. Teachers Reaction to the Place of Storage of Scientific Equipment Used by Them in the Classroom or Laboratory 213

LIST OF ILLUSTRATIONS

Figure Page

1. Recommended Minimum Academic Preparation of Earth Science Teachers in a Four-Year Baccalaureate Program 18

2. Sample Work Sheet for the Dale-Chall Formula. . . 110

3. Passage with Lowest Reading Difficulty Score. . . 160

4. Passage with Highest Reading Difficulty Score . . 162

5. Readability Scores Plotted by Chapters Basic Earth Science 177

6. Readability Scores Plotted by Chapters Earth Science: The World We Live In 178

7. Readability Scores Plotted by Chapters Modern Earth Science 179

8. Readability Scores Plotted by Chapters Exploring Earth Science 180

9. Readability Scores Plotted by Chapters Modern Science 181

10. Readability Scores Plotted by Chapters Science is Understanding 182

11. Readability Scores Plotted by Chapters The Earth Sciences 183

12. Readability Scores Plotted by Chapters Investigating the Earth 184

13. Map showing the Colleges and Universities supported by the State of Texas and the counties from which completed questionnaires were returned 190

14. The Number of Teachers who have taken courses in Astronomy plotted against the number of Astronomy courses taken 193

TEXTBOOK READABILITY AND OTHER FACTORS WHICH COULD INFLUENCE THE SUCCESS OF THE EIGHTH-GRADE, EARTH SCIENCE COURSE IN THE TEXAS PUBLIC SCHOOLS

by

Loren E. Kline, Jr.

CHAPTER I

INTRODUCTION

In November, 1964, when the Texas Education Agency adopted three earth science textbooks,[1,2,3] it was following recommendations made five years earlier by curriculum committees of the agency. It was also following a rapidly developing trend in which earth science was replacing general science in the junior high school curriculum.

Only one institution of higher learning in Texas offers teacher certification programs for earth science teachers. This fact is not apparent to the teachers because of the name given to the program by the Texas Education Agency. They consider earth science to be one of the four options of a Broad Field Science Program. As a result, there exists the possibility that Texas might not have enough teachers who have taken earth science courses to teach this new material.

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[1] Helen D. MacCracken, Donald G. Decker, John G. Reed, and Alton Yarian, Basic Earth Science (Syracuse: The L. W. Singer Company, 1964).

[2] Samuel N. Namowitz and Donald B. Stone, Earth Science: The World We Live In (3rd ed.; Princeton: D. Van Nostrand Company, Inc., 1965).

[3] William L. Ramsey and Raymond A. Burckley, Modern Earth Science (New York: Holt, Rinehart and Winston, Inc., 1961).

Each scientific discipline has its own specialized tools and equipment. Because new and sometimes expensive instruments are necessary for instruction in this new program, there is the possibility that some of the schools might not have all of the equipment they would need to present the new earth science subject matter.

For the past fifteen years George G. Mallinson has been studying the readability of science textbooks. His research, which will be quoted in a later section of this work, indicated that in general most science textbooks were written at reading levels which were much higher than the grades for which they were intended.

If the teachers of Texas are not well prepared to present earth science, if the schools are not adequately equipped to offer this subject, and if the textbooks have been written at a level too high for the students for whom they were intended, earth science could be considered a subject that is not suitable for junior high schools for reasons totally unrelated to the subject matter of the discipline. It was to investigate these three possible areas of difficulty that this study was undertaken.

Statement of the Problem

The problem examined by this study was twofold. Its purpose was (1) to determine the reading difficulty of the textbooks adopted for use in the eighth-grade science classes of the public schools of Texas; and (2) to determine how well the teachers were prepared and how well the schools were equipped to present a course in earth science.

Method of Study

The reading difficulty of the textbooks was determined by means of the Dale-Chall formula for predicting readability.

Teacher preparation and equipment requirements of the Texas public schools was determined by means of questionnaires sent to 252 of the 254 counties in Texas. The data concerning the preparation of the teachers were compiled up to and including the end of the spring semester of the 1964-65 academic year. The material requirements necessary for the teaching of earth science in the Texas public schools were determined by means of a systematic study of the three textbooks adopted by the state in November, 1964.

Limitations

This study was limited to the situation as it existed at the close of school in May and June, 1965.

How well a textbook was suited to the grade in which it was used was based only upon its reading level. In order to be suitable for a particular grade, the textbook had to have an average reading difficulty no higher than that grade. Better yet, its reading level should be approximately one grade lower than the grade in which it was to be used. The reading level was determined by means of the Dale-Chall formula for predicting readability.[1]

Historical Background

Collegiate education in the sciences, in the United States, did not begin until the eighteenth century,[2] but it was not until the passage of the Morrill Act in 1862 that institutions of higher learning devoted to scientific studies came into widespread existence.

For the next forty years the land grant colleges developed their own curriculum, and also much of its content, based upon scientific investigations conducted by them.[3] This development of curriculum was accompanied by a filtering down process, and in the 1880's the high schools began to develop curriculums to prepare students for admission into the land grant colleges. The shortage of teachers for these courses resulted in the Nelson Amendment of 1907 which provided funds for the education of teachers in agriculture and the mechanic arts.[4]

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[1] Edgar Dale and Jeanne S. Chall, "Formula for Predicting Readability," _Educational Research Bulletin_, (XXVII, January 21 and February 17, 1948).

[2] John S. Brubacher and Willis Rudy, _Higher Education in Transition_ (New York: Harper and Row, Publishers, 1958), pp. 15-20.

[3] Arthur J. Klein, _Survey of Land-Grant Colleges and Universities_, United States Department of the Interior Bulletin, 1930, No. 9, 2 vols. Vol. 1 (Washington: U. S. Government Printing Office, 1930), p. 21.

[4] _Ibid_., p. 27.

The scientists, who had been accumulating the basic knowledge in the land grant colleges and in other institutions, wrote the textbooks for both the university and high school courses. As a result, the textbooks written between 1890 and 1929 were largely scientific treatises, factually as accurate as the knowledge of the day, but written with little regard for the difficulty of the material nor with how the teachers were to present it. In spite of these deficiencies, "the basic model for the conventional science textbook was laid down for the high school of 1890-1929."[1]

Because the high schools of this period were in the main college preparatory, they tended to have a rather homogeneous student body, and the problems created by extreme ranges of ability were minimal.

The end of World War I brought a rapid expansion of the social sciences and a gradual withdrawal of the physical scientist from the field of textbook writing. During the period from 1929 until 1957 the physical scientists almost completely abandoned the public schools. If educators had not been concerned with both the welfare and scientific literacy of their students, education in the physical sciences might have disappeared from the public schools of the United States. Because the physical scientists had abandoned them, the writing of textbooks now became the obligation of people who were not specialists in these particular disciplines. As a result "their content was no longer mainly determined by the state of knowledge in the scientific field and the portion of knowledge thought necessary for college work. Instead, many materials were omitted or emphasized on the basis of views as to what could be most easily taught. Still other material was modified to conform to theories of teaching and learning regardless of the extent to which these modifications presented a distorted view of the subject as known by the scientists."[1] This was in part because the high school now catered to more nearly the whole population, and not just the college bound. This greater diversity of the student body caused a need for textbooks that could provide terminal education and not just preparation for the continuation of the study of that subject in college.

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[1] Joseph J. Schwab, Biology Teachers' Handbook (New York: John Wiley and Sons, Inc., 1963), p. 4.

Another factor causing this change was that the rapid expansion of the high school enrollment created a shortage of teachers. The need for more and more teachers was "met by reducing both the quality and quantity of their training,"[2] particularly in science. This made the teacher less able to deal with a highly scientific textbook.

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[1] _Ibid._, pp. 5-6.

[2] _Ibid._, p. 6.

While the textbook became easier for the student to use and learn from, and while they became easier for the teachers to use as a basis for their teaching, the loss of the scientist from the writing of textbooks resulted in their becoming static, oriented to past content, and to become farther and farther removed from the actualities and realities of modern science. Examples of this can be found in the teaching of geography. Physical geography gradually disappeared from the curriculum, and if it was replaced, social geography took its place. From 1957 to 1965 less than 5000 physical geography textbooks were sold to the schools of Texas.[1]

Older science courses, such as physical geography, botany, zoology, and physiology practically disappeared from the science offerings of public secondary schools.[2] Science came to be represented by courses called by such titles as "senior science," "consumer science," or "physical science."[3]

The rapid expansion of science and technology following World War II raised some questions concerning this trend.

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[1] J. B. Golden, Director, Textbook Division, Texas Education Agency, personal communication.

[2] Nelson B. Henry (ed.), _The Forty-Sixth Yearbook of the National Society for the Study of Education: Science Education in American Schools_ (Vol. XLVI; Part 1; Chicago: The University of Chicago Press, 1947), p. 276.

[3] _Ibid_., p. 2.

> The need for a reorientation of science teaching has been apparent since the early 1940's. The advances in science, its 'breakthroughs,' its growing unity, the 'explosion of knowledge,' its importance as an element in our way of life, and its significance in the economy of our nation all suggested new directions for science teaching. It was apparent that this would require an education *different in kind* from that ever before offered young people.[1]

This fact had been concealed from the general public by the depression of the 1930's and the wars of the 1940's. As concern mounted, it was realized that neither the scientist nor the educator working alone had produced a textbook which met the needs of the day. Gradually scientists and educators began to combine their talents in an effort to do together what neither had accomplished alone.[2]

As would be expected, the language of science was the first to respond to the need for modernization. In 1951 the University of Illinois Committee on School Mathematics Project was instituted.[3] The Ball State Teachers

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[1] Paul DeHart Hurd, "The New Curriculum Movement in Science," *The Science Teacher*, (XXIX, February, 1962), p. 7.

[2] Schwab, p. 7.

[3] National Council of Teachers of Mathematics, *The Revolution in School Mathematics*, Kenneth E. Brown, "*The Drive to Improve School Mathematics*." A Report of Regional Orientation Conferences in Mathematics (Washington: National Council of Teachers of Mathematics, 1961), p. 19.

College Experimental Program followed in 1954.[1] In 1955 a study was begun by the Commission on Mathematics of the College Entrance Examination Board.[2] The University of Maryland Mathematics Project started in 1957.[3] Four programs were begun in 1958.[4] They were the School Mathematics Study Group of the Naional Science Foundation, Yale, and Stanford Universities;[5] the Greater Cleveland Mathematics Program;[6] the Madison Project of Syracuse University;[7] and Geometry for Primary Grades of Stanford University.[8] The Boston College Mathematics Institute[9] and the University of Southern Illinois programs began in 1960.[10]

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[1] Ibid., p. 20.

[2] Ibid., pp. 20-21.

[3] Ibid., p. 19.

[4] Ibid., p. 19.

[5] Ibid., p. 18.

[6] Terry Ferrer, Classroom Revolution, Reprinted from the Herald Tribune (New York: New York Herald Tribune, Inc., 1963), p. not numbered, last page.

[7] Ibid.

[8] Ibid.

[9] National Council of Teachers of Mathematics, pp. 19-20.

[10] Ibid., p. 20.

The efforts directed toward the modernization of mathematics were followed by similar efforts directed at the modernization of the teaching of the various disciplines of science. The Physical Sciences Study Commission was organized at the Massachusetts Institute of Technology in 1956 to study and revise the teaching of physics.[1,2] The Chemical Bond Approach to the study of chemistry grew out of a conference held at Reed College in 1958.[3] The Chemical Education Materials Study approach grew out of a committee meeting of the American Chemical Society held at the University of California at Berkeley in 1959.[4,5] Also in 1959, the American Institute of Biological Sciences established the Biological Sciences Curriculum Study to revise biology textbooks.[6] In 1958 discussions about and experimentation with books designed to aid teachers were begun by the

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[1] Ferrer, p. last page.

[2] Paul F. Brandwein, "The Revolution in Science Education: An Examination of the New Secondary Science Curriculums," Teacher's Notebook in Science (New York: Harcourt, Brace and World, Spring, 1962), p. 6.

[3] M. Gilbert Burford and Harry F. Lewis, "The Wesleyan Conference of 1958: One Approach or Several?" Journal of Chemical Education, (XXXVI, February, 1959), p. 90.

[4] R. L. Silber, "The Chemical Education Materials Study Approach to Introductory Chemistry," School Science and Mathematics, (LXI, February, 1961), pp. 114-115.

[5] Brandwein, p. 7.

[6] Ibid., p. 6.

American Geological Institute. Based upon the experience thus gained, in 1963 the AGI set up the Earth Science Curriculum Project as an effort to bring the teaching of earth science back into the public schools.[1]

In addition, there are four curriculum projects for elementary schools. These are The Elementary Science Study of the Educational Services, Inc., Project on Science Instruction in Elementary and Junior High Schools of the National Science Foundation and the American Association for the Advancement of Science, University of California Elementary School Science Project of the National Science Foundation and the University of California, and the University of Illinois Elementary School Science Project of the National Science Foundation and the University of Illinois.[2] The Junior High School Science Project of Princeton University contains earth science, chemistry, and physics.[3] The two thirteen year approaches are the Science Curriculum: K-12 approach of the National Science Teachers Association, and the Science Curriculum Program of the Science Manpower Project sponsored by several corporations and foundations and Teachers College, Columbia University.[1] The American Chemical Society sponsors a third project, Chemistry: An Introductory Course.[2]

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[1] American Geological Institute, Investigating the Earth, Teacher's Guide, Robert L. Heller and Chalmer J. Roy, "Foreward," (Denver: American Geological Institute, 1964), pp. v-vi.

[2] Using Current Curriculum Developments, Paul E. Blackwood, "Science," A Report of Association for Supervision and Curriculum Development, Commission on Current Curriculum Developments (Washington: Association for Supervision and Curriculum Development, 1963), pp. 63-64.

[3] Ibid., p. 67.

Curriculum projects have been organized in many other fields. There are at least two in the arts, three in English, five in foreign languages, eight in physical education, four in reading and writing, and twenty in the social sciences.[3,4,5]

These programs were intended to be national in scope. The various states, however, began experimenting with new programs on their own initiative. In 1956 the Texas Association of School Administrators, in cooperation with the Texas Education Agency, held a conference whose purpose was the "improvement in the administration of school instructional programs."[6] This study carefully reviewed the teaching of science, indicated that it should be carried on throughout the twelve grades, and should include elements of earth science.

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[1] Ibid., p. 68.

[2] Ibid., p. 67

[3] Ibid., pp. 11-85.

[4] Dorothy M. Fraser, Current Curriculum Studies in Academic Subjects (Washington: National Education Association, 1962), pp. 43-85.

[5] Ferrer, last page.

[6] Texas Association of School Administrators, The School Superintendent in the Science Program, 1956-59 Project, Bulletin 8, October, 1956, p. 111.

The following year a few schools began teaching physical geography, an approach to earth science. The very small scale of this teaching is indicated by the sale, through the Texas Education Agency, of the textbook written by Samuel N. Namowitz and Donald B. Stone _Earth Science: The World We Live In_, and which was copyrighted in 1953. The number of textbooks sold from the year of its adoption until 1965 is shown in Table 1.

TABLE 1[1]

NUMBERS OF COPIES SOLD FROM DATE OF ADOPTION TO THE PRESENT*

School Year	Number of Copies Sold
1957 - 1958	778
1958 - 1959	270
1959 - 1960	110
1960 - 1961	363
1961 - 1962	0
1962 - 1963	2,480
1963 - 1964	342
1964 - 1965	163

*Samuel N. Namowitz and Donald B. Stone, _Earth Science: The World We Live In_ (3rd ed.; Princeton: D. Van Nostrand Company, Inc., 1965).

[1] Golden, personal communication.

On October 4, 1957, Russia successfully flew her Sputnik I. As a direct result of Sputnik, Texas conducted a state-wide curriculum study. These Texas Curriculum Studies, which were authorized by the State Board of Education in January, 1958, suggested major revisions in the science curriculum of grades seven, eight, and nine. It was suggested that life sciences should be taught in the seventh-grade; earth sciences in the eighth-grade; and the physical sciences, an introduction to chemistry and physics, in the ninth-grade.[1] Earth science was suggested for the eighth-grade to replace general science. It was believed that general science was no longer doing the things for which it had been intended.

The recommendation that earth science be substituted for general science in the eighth-grade presented a peculiar problem. A course of study had been recommended for the schools of Texas before a teacher certification program had been developed. This created a situation in which a course could be offered before there were qualified teachers to teach it and before there was any program organized so that they could become qualified.

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[1] Texas Curriculum Studies, Report of the Commission on Science, Report No. 4 (Austin: Texas Education Agency, July, 1959), pp. 13-19.

In June, 1959, personnel in both the administration and science departments of East Texas State University developed an Earth Science Division in the Physics Department. This new division started with a few courses. In 1963 a program permitting either an academic specialization of eight earth science courses (major specialization) or an academic specialization of six earth science courses (minor specialization) for an elementary teaching certificate was approved by the Texas Education Agency. Later in 1963, a Broad Field Science Program, with a major in earth science, for a secondary teaching certificate was approved. This Broad Field Program is composed of three courses in geology, one in astronomy, one in meteorology, two earth science electives, and two - one hour seminars, for a total of twenty-eight credit hours in earth science. In addition, the student must also take three physics courses, three chemistry courses, three biology courses, and two mathematics courses. These two courses must be college algebra and trigonometry or higher. The requirements for this Broad Field Option, one of four possible options, are higher than those recommended by the Earth Science Curriculum Project.

In June, 1964, earth science became a separate department of East Texas State University.[1]

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[1] Roy N. Jervis, Head, Department of Earth Science, East Texas State University, personal communication.

On November 9, 1964, about five years after the Texas Curriculum Study Commissions had issued their reports, the Texas Education Agency adopted three earth science textbooks. These books were:

Basic Earth Science by MacCracken, Decker, Read, and Yarian

Modern Earth Science by Ramsey and Burckley

Earth Science: The World We Live In by Namowitz and Stone, Third edition.

On November 10, 1964, representatives from eighteen colleges met with Dr. Milo Kearney, Director, Division of Teacher Education and Certification, to set up a program for the certification of teachers of earth science. The policy of the Texas Education Agency prevents the establishment of a certification program until more than 10,000 textbooks have been sold in Texas; therefore, the certification program in earth science was turned down. In spite of this, from November, 1964, to September, 1965, 159,440 earth science textbooks were sold to the public schools of Texas by the Texas Education Agency.[1]

It could, therefore, be assumed that the teachers who were to teach the courses for which these books were sold, were not likely to be qualified to teach this material under the normal standards of certification which had applied to other courses that had been taught in the Texas public schools. This lack of preparation should be considered in terms of the requirements recommended for earth science teachers by the scientists and educators who comprise the Earth Science Curriculum Project. These recommendations are quoted in Figure 1.

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[1] Golden, personal communication.

In the original recommendations prepared in June, the Conference participants recommended that each teacher should have in his undergraduate work a six weeks (six semester hours) field camp experience in geology or oceanography. This was later amended to the recommendations shown in Figure 1 because many small teachers colleges would not have adequate staff or enough students to offer a worthwhile field course. However, in recommendations published in 1966, the need for field experience was again included.[1]

The difference in preparation between what the specialists in the field of earth science education recommend and what the Texas teachers are likely to have indicates that it is possible that the teaching of earth science during the first year of the adopted program could encounter difficulty.

Most, if not all, of the national curriculum projects

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[1] John W. Shrum, "Recommendations for a Basic Academic Preparation for Earth Science Teachers," Journal of Geological Education, (XIV, February, 1966), p. 27.

FIGURE 1

RECOMMENDED MINIMUM ACADEMIC PREPARATION OF EARTH SCIENCE TEACHERS IN A FOUR-YEAR BACCALAUREATE PROGRAM*

(Revised October 1965)

A. EMPHASIS IN EARTH SCIENCE

1. Minimum of 30 Semester Hours in Earth Science

   Earth science is here defined as the study of the earth as a whole--(1) the solid earth, (2) the atmosphere, (3) the hydrosphere, and (4) earth's environment in space. The approach is based in the physical and biological sciences and their role in the evolution of the earth.

   a. Studies including investigative laboratory work in three of the four areas above

   b. 12 semester hours of junior-senior level courses in one or two of the four areas above

   c. a full-time period of practical experience (field and/or laboratory problem course) in one of the four areas above

B. EMPHASIS IN RELATED SCIENCES

1. Minimum of 30 hours to include Courses in Each of the Following Areas:

   a. chemistry

   b. physics

   c. biology

   d. mathematics

* Recommendations resulting from a Conference on the Preparation of Earth Science Teachers held at ESCP Headquarters, Boulder, Colorado, on June 25 and 26, 1965, and modified by suggestions from the Conference participants, ESCP Steering Committee and the ESCP Teacher Preparation Advisory Committee.

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were tested and revised, at least once, in order to increase the chances that they would be successful teaching devices. Not only were they tested, but the teachers also received instruction, in summer institutes and conferences, in how to present this new material. In addition, the teachers also had members of the staff of the project available to them for consultation and guidance. It should, therefore, be obvious that advance planning is necessary before a new subject can be put into the curriculum.

> It would be sheer folly to believe, simply because the new curriculums have been tested and proved, that you can buy the textbooks today and start teaching tomorrow. In the first place, all of the new curriculums require a different kind of teaching. There's a bright, new philosophy of instruction which stands behind current science education. Teacher attitudes and methods will have to change, and you'll have to prepare your faculty through in-service training. Additionally, the new courses carry implications for change in science facilities--laboratories, equipment, materials. You may find that your high school schedule will be affected by the new curriculums (they require more time).
>
> In short, the only districts which are really prepared to teach the new sciences in September, are the ones which have spent recent months carefully planning for the change. If your district is not blessed with teachers who have been trained in the new curriculums, then you are better off spending the next 12 months getting ready for a September 1964 start.[1]

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[1] "The 'New Science Curriculums:' How to Get Your District Ready," School Management, (VII, June, 1963), p. 59.

The earth science program which was adopted by Texas has never been tested. It is also quite likely that the teachers have had very little preparation, and quite likely no specific advance preparation, to present this earth science material. Quite probably the only advance preparation was made by those teachers who attended college during the summer, on their own initiative, and took those courses which they felt would be of most benefit to them.

The National Science Foundation sponsors Summer Institutes for teachers. During the summer of 1965, three institutes were held in astronomy, one of these was held in Texas. Thirty-seven Summer Institutes were held in earth science, three of these were held in Texas. Sixteen were held in general science and these included some work in the earth sciences. Two of these institutes were held in Texas. One institute was held, not in Texas, in geography. Twenty-seven institutes were held in multiple fields, which included earth science. One of these was held in Texas.[1] This institute was held at East Texas State University. A total of 384 applications were received from teachers. Those applicants represented 43 states and one foreign country.

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[1] National Science Foundation, "Summer Institutes for Secondary School Teachers of Science and Mathematics--1965," (Washington: National Science Foundation, December, 1964).

A total of 42 applicants were accepted. These teachers came from 15 states. Of the 42, who were accepted, 22 were Texans.[1] If the 84 Summer Institutes, which in whole or in part included earth science, each offered instruction to 50 teachers, only 4,200 of the nation's teachers could have attended. If the seven institutes held in Texas could offer instruction to 50 teachers, only 350 could have attended. This is less than the number of teachers who responded to the questionnaire sent out for this study.

The chief problem relating to the introduction of earth science into the eighth-grades of Texas is that the program has no sponsor. As a result, there is no organized group to which the teachers can turn for help and guidance. This is not the case when a school adopts a program sponsored by one of the national curriculum projects. In the case of Texas earth science, the only help which the teachers have will come from the colleges and universities which have the time and willingness to help them.

And yet "*the most successful innovations are those which are accompanied by the most elaborate help to teachers as they begin to provide the new instruction*. . . . It became vividly clear during the survey observations the key to successful innovation is assistance to the teachers."[1]

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[1] Charles S. Rohrer, Head, Department of Chemistry, Director of the National Science Foundation Project, East Texas State University, personal communication.

The present earth science program has no sponsor. There is only one institution of higher learning in the state with a program leading to teacher certificates for earth science teachers. The key to successful innovation is assistance to the teachers. Considering these three points, it would seem reasonable to assume that a large number of earth science teachers are likely to be poorly prepared to teach this new course. Would it not also be reasonable to assume that a poorly prepared teacher would do a poorer job of teaching than a well prepared teacher?

> The real source of rigidity in an educational program is not the written guide or textbook, but is the teacher who knows no more about the subject than is contained in that guide or book. He is constricted by it in the sense that it is the limit of what he knows. It is his only map to an unknown land.
>
> The consultant had the rare opportunity of observing hundreds of teachers doing things they had never done before. It did not take long to discover that those who taught a new elementary mathematics or foreign language program with ease and flexibility were those who knew more math or language than the program called for. It was equally evident that those who followed written material with lock-step precision were those who had not been educated out beyond it.[2]

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[1] Henry M. Brickell, Organizing New York State for Educational Change, A report made to the Commissioner of Education under a grant made by the Fund for the Advancement of Education of the Ford Foundation to the University of the State of New York, State Education Department (Albany: December, 1961), p. 31.

[2] Ibid., p. 32.

If it can be assumed that the teacher who teaches with ease and flexibility is a better and more interesting teacher than one who follows the written material with lock-step precision, then it would appear that the first teacher would receive a better student reaction than the second teacher.

> *Instructional innovations are almost always evaluated by observing the reactions of the students while they are receiving the new instruction. In the eyes of the practicioner, no other evidence outweighs student reaction as a measure of success. More complex evaluative techniques are rarely used*. . . . Instructional procedures to which students react with interest or enthusiasm are ordinarily judged to be successful. Few programs are given more intensive evaluation. Few school systems require anything more intensive before concluding that the new aproach should be spread into other classes and other grades.[1]

If the line of reasoning is true that poorly prepared teachers are likely to have a poor student reaction to their course, and if it is true that Texas has many teachers poorly prepared to teach earth science, then it should follow that factors other than the importance or lack of importance of the earth science material will determine whether or not the course will continue to be taught in Texas public schools.

If at the end of the 1965-1966 school year student reaction to the new course in earth science is less than enthusiastic, and there is no information available to explain this reaction, it is possible that those concerned with the program will decide to return to the security of the ineffective, but safer, general science.[1,2]

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[1] *Ibid*., p. 33.

The short term effect is a failure of an area of study which could have an effect upon the education of many young Texans. But the short term effect does affect longer term things. The exploration of outer space is based upon a knowledge of the earth and its environment. If a person lacks this knowledge, he is poorly equipped to vote on issues concerning this activity.

There are much more personal effects of a lack of knowledge about the earth and the forces which act upon it as anyone who has lost property in a flood or landslide will testify. As cities expand they are quite apt to grow into places poorly suited for safe habitation. Newspaper stories indicate that many people have lost their property because of these things. This is particularly true in California.[3] The individual who has learned something about the earth, and the forces which act upon it is better prepared to make

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[1] Hugh M. Davison and H. Seymour Fowler, "Earth Science Course Evaluation: What Do They Learn in Earth Science?" Science Education, (XLIX, March, 1965), pp. 184-185.

[2] Donald Schmidt, "Attempts with Curriculum Design in the Secondary School," School Science and Mathematics, (LXV, June, 1965), p. 570.

[3] Richard H. Jahns, Dean, College of Mineral Industries, The Pennsylvania State University, personal communication.

a wise selection of the areas in which he chooses to live.

These are the more immediate effects of education in the earth sciences. The professional earth scientist, however, sees much more important long term effects. He is joined by scientists from all of the other disciplines in an awareness of the fact that the general public is not fully aware of the broad significance and the important role which modern science plays in their daily lives.[1] Science education is as important for survival of modern man as is reading, writing and arithmetic.

> Dr. Harrison Brown of the California Institute of Technology places science in a position of fundamental importance and emphasizes the role of science education. He reasons that because man has moved from an environment of nature to one of his own making, and has become dependent on the smooth maintenance of that environment for his survival, he must learn to accelerate his accumulation of knowledge to be able to keep that maintenance smooth.
>
> Dr. Brown likens our dependence on science and technology to the dependence of the Irish in the 19th century on the potato. After the introduction of the potato to Ireland in the 17th century, this crop, which was particularly adaptable to Ireland's terrain and agricultural methods, became the mainstay of the country. So successful was the crop that in the years between 1700 and 1800 the population of Ireland doubled and by 1841 reached eight million, with three-fourths of the population dependent on the potato for survival.
>
> In 1846, however, the potato blight, which had struck all northern Europe, reached Ireland, resulting in one of the most dreadful famines in history. By 1851 the population had been cut to six and one-half million--three quarters of a

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[1] Henry, pp. 289-296.

> million were dead, another three quarters of a million had fled the country.
>
> Dr. Brown says, "Today our complex industrial network is to us what the potato was to the Irish. We in the West have become as dependent for our survival upon our science and our technology as the Irish became dependent upon the potato."
>
> Dr. Brown further states that solving the complex problem of survival which we must face will require people with a broad view of man's world and his place in it--"men and women who are truly well-educated, far above the level which is accepted today as perfection." The savage in the jungle is better equipped to survive in his world than we are in ours. The savage who does not understand his own tools and the plants and animals around him does not long survive. So we must understand our complex industrial civilization in order to survive in it.
>
> . . . .
>
> Thus, it is obvious that one role of science education is training our citizens to understand the scientific world in which we live and preparing enough of them to be able to pass the frontier of knowledge necessary for adding new information required to maintain and expand science, technology, industry, and the well-being of man and our civilization. The alternative is that civilization--and perhaps man also--will become extinct. It is important for us to realize that this is what has happened to most living forms that have appeared on earth, to other civilizations and cultures, and to nations.[1]

If science is this important to the survival of modern man, anything which causes a breakdown in the teaching of any branch of science represents a serious threat to the chances of future generations for survival.

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[1] Addison E. Lee, "Current Problems in Science Education," *Science Education*, (XLIX, March 1965), pp. 146-147.

If the new earth science program turns out to be unsuccessful, those involved with it should have all of the information possible concerning why these unfavorable results were obtained. This information is essential in order to bring about a successful program. If on the other hand, the program is a success, the information will serve as a foundation upon which a better program can be built. In order to meet these needs, this study was undertaken.

Significance of this Study

Earth science is an important component of the structure of man's knowledge. There is evidence that the earth science course adopted ty the State of Texas will not achieve what is expected of it. This could result from one or more factors. The state adopted textbooks may prove to be unsuitable for use in eighth-grade classes. The effectiveness of the teachers may be limited by a lack of preparation. The schools may be inadequately equipped. Poor results could thus be obtained because of things other than the content of this branch of science. As a consequence, those who evaluate the results of this first year's experience with earth science teaching should have as much information as possible about the situation upon which to base their judgments. The course should not be abandoned for reasons which are not related to its subject matter. Today's students need a knowledge of earth science to understand today's world. In the long term, mankind needs this information to better his chances for survival. This study was made to provide information upon which a better earth science program can be built.

Definition of Terms

Certain terms used in this study are defined in the following way.

The Dale-Chall formula for predicting readability is a method for determining the reading difficulty of written and spoken material. It is based upon the number of words in the sample not on the Dale list of 3,000 familiar or easy words, and upon the average length of the sentences, in words.

Earth science is the study of the earth, its history, its environment, and the forces which act within and upon it. The subject matter areas usually included within the field of earth science are astronomy, geography, geology, meteorology, mineralogy, oceanography, paleonology, and paleontology.

Palynology is the study of ancient and existing plants and plant parts, with special emphasis upon the microscopic sized parts such as pollen and spores.

Paleontology is the study of ancient life and any evidence of its existence. It is popularly referred to as the study of fossils.

Readability consists of the quantitative elements of style influencing the degree of comprehensibility of written material, in terms of average sentence length and the proportion of unfamiliar or hard words.

Reading level is the point at which written material is understandable to 50 per cent of the readers. In this study several other terms are considered to have the same meaning: *level of reading difficulty*, *readability index*, *grade placement*, and *grade placement score*.

Unfamiliar words are words which do not appear on the Dale list of 3,000 familiar words. *Uncommon words*, *difficult words*, and *hard words* are used synonymously with *unfamiliar words*.

Vocabulary load is the proportion of uncommon words in written material.

CHAPTER II

REVIEW OF RELATED LITERATURE

Two methods of research were required in studying this problem. One method was concerned with the measurement of the reading difficulty of textbooks, and the other with the survey of Texas teachers and schools. As a result, throughout the remaining parts of this work readability and the Texas teacher and school survey will be considered separately.

READABILITY

Historical Background

Today the average American adult knows how to read. Most are reasonably well skilled in this task. As a result, few adults remember the trials and tribulations they suffered as children in developing this skill. Yet, learning to read is a major developmental task for the twentieth century, American child.

> Developing an understanding of written and verbal symbolism is an essential developmental task for normal children growing up in our society. The extent to which a child is successful in manipulating and comprehending these symbols influences his chances of self-realization. Methods used and materials presented to children

> tend either to hinder or facilitate normal growth in learning to read and reading to learn.[1]

Because of the importance of the role which reading plays in modern education "Efforts to bring the level of reading difficulty of written materials more nearly in line with the reading ability of those for whom the materials are written have been extensive."[2]

There are many things which affect the ease or difficulty with which a passage can be read and understood by the reader. These factors have been grouped together under the title of readability, and Dale and Chall define readability as the

> sum total of all those elements within a given piece of printed material that affects the success a group of readers have with it. The success is the extent to which they understand it, read it at an optimum speed, and find it interesting.[3]

There are many elements within a piece of printed material that affect the success that readers have with it. During the past sixty years many of these elements have been defined and examined. But, like all other research this has not been a smooth, paved, easily traveled highway from the known to the unknown. Instead, it has been man's' unceasing struggle with his own ignorance. As will be shown in the chronological account which follows, in the beginning the efforts were few and halting, but as more and more workers applied their talents the curtain of darkness was pushed back. This was not done in a smoothly flowing orderly way, but in the chaotic manner in whch all research advances. This is because one man's work and ideas fertilize and stimulates the thinking and work of another. Oftentimes this stimulation takes the new worker in quite a different direction and different area of study from the one who provided the inspiration. But in spite of this, each person contributed his share to the ever expanding frontier of knowledge.

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[1] Fred A. Sloan, Jr., "Readability of Social Studies Textbooks for Grades Four, Five, and Six as Measured by the Dale-Chall Formula," (unpublished Doctoral dissertation, George Peabody College for Teachers, 1959), p. 20.

[2] Ibid., p. 21.

[3] Edgar Dale and Jeanne S. Chall, "The Concept of Readability," Elementary English, (XXVI, January, 1949), p. 23.

In this way the research for an easy to use, accurate method to measure the degree of difficulty a reader would have with a given passage of written material went on. While the efforts of all of these researchers have not as yet produced the perfect measuring instrument, some things have been learned, and some reasonably accurate formulas have been developed based upon many and very different approaches to this problem. As Chall points out, these varied pieces of research do tend to have a common thread.

> Every study of readability has measured some aspect of vocabulary load. These have been measured either against word lists or by counting syllables, abstract words, affixed morphemes, and so on. All counts of vocabulary load correlated highly with one another, and so can usually be used in place of

another if adjustments in the formula are made.[1]

Because vocabulary appears to be, at present, the most reliable measure of reading difficulty, this study of readability will be primarily concerned with the vocabulary aspects of readability.

One of the earliest studies of vocabulary appeared in 1904. It was made by Chambers.[2] Another appeared in 1915. It was presented by Ayers.[3] A third, by Thorndike,[4] was published in 1921. This was the first of a series of books by Thorndike, and it was entitled _Teacher's Word Book of 10,000 Words_. The work of these three men, particularly Thorndike, caused educators and writers to become more concerned "about the relationship of the reading difficulty of written material to the comprehension and reading skill of the person for whom it was written.[5]

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[1] Jeanne S. Chall, "This Business of Readability," _The Educational Research Bulletin_, (XXVI, January, 1947), p. 8.

[2] Will Chambers, "How Words Get Meanings," _Pedagogical Seminary_, (XI, March, 1904), pp. 30-50, quoted from Hyman Haffner, "A Study of Vocabulary Load and Social-Concept Burden of Fifth and Sixth Grade Social Studies, History, and Geography Textbooks," (unpublished Doctoral dissertation, University of Pittsburgh, 1959), p. 5.

[3] L. P. Ayers, "Measurement of Spelling Ability," _Educational Monograph_ (New York: Russell Foundation, 1915). Quoted from Haffner, p. 5.

[4] Edward L. Thorndike, _Teacher's Word Book of 10,000 Words_ (New York: Teachers College, Columbia University, 1921).

[5] Sloan, p. 21.

In 1922 Selke and Selke approached the problem of vocabulary in a different way. They were concerned about the commonality of words in books for very young children. They found a lack of any developmental design in the twelve primers which they studied. From a total of 1,636 different words contained in these books, they found only thirty-eight that were common to all twelve.[1] This was one of the first studies to call attention to the fact that authors and publishers had very little knowledge about how to relate the books they were creating to the readers for whom they were intended.

Lively and Pressey were the first to attempt to determine the factors which contributed to the difficulty of written materials. In a study published in 1923, they hypothesized that three factors could be used to determine reading difficulty: (1) the "vocabulary range" or number of different words; (2) the weighted median index number as determined by Thorndike's *Teacher's Word Book of 10,000 Words*; and (3) the number of words not appearing in Thorndike's most common 10,000 words.[2] The weighted median index was calculated in the following way: Each word within the 10,000 most common words was given a numerical value from one through ten, depending upon the frequency group in which it was found in Thorndike's list. The value of zero was given to each word not found in that list. Each zero-classified word was counted twice. The median was then determined from the combination of values in these two groups.[1]

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[1] Erich Selke and G. A. Selke, "A Study of the Vocabularies of Beginning Books in Twelve Reading Methods," *Elementary School Journal*, (XXII, June, 1922), pp. 745-749.

[2] Bertha A. Lively and S. L. Pressey, "A Method for Measuring the 'Vocabulary Burden' of Textbooks," *Educational Administration and Supervision*, (IX, October, 1923), pp. 392-394.

The results of this investigation indicated that vocabulary range, even when so classified and arranged, did not distinguish difficult material from easy material. It did indicate that the words which did not appear on the Thorndike word list were important in determining the degree of difficulty of certain materials. These workers found the best indicator of vocabulary burden to be the weighted median index. A high median index number indicated an easy vocabulary.[2]

Lively and Pressey concluded that an estimate of reading difficulty of a written work could be derived from scientifically selected 1000-word samples spaced throughout the material.[3] This investigation stimulated interest in readability and other workers began to make readability studies.

In 1926 Washburne and Vogel developed their Winnetka formula. This was the first formula to analyze the structural characteristics of books prepared for children, and was the first to establish reading difficulty by grade levels. This study was based upon the books which children read and how the children, themselves, evaluated the ease with which they could be read. The results of this study were published in the book, What Children Like to Read: Winnetka Graded Book List.[1]

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[1] Ibid., pp. 390-391.

[2] Ibid., pp. 392-394.

[3] Ibid., pp. 396-398.

Washburne and Vogel next turned their attention to another facet of readability. They decided to learn if it would be possible to develop a formula to analyze new books for grade placement as they were published. In 1928 they presented a four-factor formula for predicting the grade placement of books. These four factors were: (1) the number of different words in a sample of 1,000 words; (2) the number of prepositions per 1,000 words, with duplicated ones being counted; (3) the number of words in the 1,000 words which did not appear in Thorndike's list of 10,000 words, with repeated words being counted; and (4) the number of simple sentences in seventy-five sentences. These four factors were determined from a study made of 1,000-word samples taken from 152 books included in What Children Like to Read: Winnetka Graded Book List, and gave a measure of reading difficulty of books for grades four through nine.[1]

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[1] Carleton Washburne and Mabel Vogel, What Children Like to Read: Winnetka Graded Book List (Chicago: Rand McNally and Company, 1926), pp. 5-10.

In 1928 Dolch examined a certain reading series from primer to fourth grade. In this study he used his combined word study list.[2] He found much the same lack of developmental design that Selke and Selke had found six years before. Dolch recommended that vocabulary load should be carefully considered in the writing of textbooks.[3]

If the vocabulary study made by Chambers in 1904 is considered to be the first work done in the field of readability, reading studies had, by this time, been in progress for about twenty-five years. Two lines of attack had thus far developed. In one vocabulary and sentence length were the variables receiving primary consideration; in the other it was how well the textbooks used at one grade level were related to each other by commonalty of vocabulary, and how well the textbooks of one grade were articulated by common vocabulary with those of the next higher grade. Both of these lines of attack have been continued through the succeeding years.

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[1] Mabel Vogel and Carleton Washburne, "An Objective Method of Determining Grade Placement of Children's Reading Material," Elementary School Journal, (XXXIII, January, 1928), pp. 373-381.

[2] Edward Dolch, "Combined Word Studies," Journal of Educational Research, (XVII, January, 1928), pp. 11-19.

[3] Edward W. Dolch, "Vocabulary Burden," Journal of Educational Research, (XVII, March, 1928), pp. 170-183.

In 1930 Johnson developed a method of estimating reading difficulty by using the number of polysyllables found in thirty samples of one hundred words each. Johnson took these samples from *What Children Like to Read: Winnetka Graded Book List* and found an increase in the ratio of polysyllabic words with the increasing grade level of the books.[1]

In 1931 Patty and Painter[2] modified Lively and Pressey's method of measuring the vocabulary load of textbooks. They determined the mean of the ratings assigned words found in the Thorndike list. The mean of these ratings was called the average-word-weighted-value. This technique was used to compare the vocabulary load of one textbook with another; however, it did not give the grade level of difficulty.[3]

A new line of attack now developed. Investigators began to examine books, not by grade, but by the subject matter area for which they were being written.

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[1] George R. Johnson, "An Objective Method of Determining Reading Difficulty," *Journal of Educational Research*, (XXI, April, 1930), pp. 283-287.

[2] W. W. Patty and W. I. Painter, "A Technique for Measuring Vocabulary Burden of Textbooks," *Journal of Educational Research*, (XXIV, September, 1931), pp. 127-134.

[3] W. W. Patty and W. I. Painter, "Improving our Method of Selecting High School Textbooks," *Journal of Educational Research*, (XXIV, September, 1931), pp. 23-32.

Brown was among the first to investigate the reading difficulty of social studies textbooks. His research, which was reported in 1931, found that the vocabularies of sixth-grade textbooks written in the field of history were more difficult than those of sixth-grade basal readers. A pupil had to know from 800 to 850 more words to use the history books than he did to use the basal readers. Brown used two other elements in his study of these textbooks: (1) the length of the words; and (2) the frequency rating of words as measured by the Thorndike ratings of word frequencies. In using these factors he also discovered that the history textbooks contained longer words and fewer common words than did the basal readers analyzed in this study.[1]

In 1932 Thorndike developed a new word list. This one was of 20,000 words taken from two hundred different sources.[2]

McClusky made a study, in 1934, to compare the elements of readability of written materials in the fields of fiction, social science, physics, and psychology. The levels of difficulty of the materials to be analyzed were determined by preparing true-false examinations from certain selected passages in each of the four fields. The scores of thirty college students were averaged to give a rank of difficulty to each type of material. McClusky found significant differences in comprehension related to sentence length; frequency of technical terms; frequency of polysyllables; and the number of common, concrete nouns. He concluded that different types of reading material represent different levels of difficulty. In this investigation the fiction passages occupied the "easy" level; and the psychology and physics passages, in that order, appeared at the "difficult" level. An analysis of passages indicated that the easy material was characterized by short, simple sentences and easy, familiar vocabulary. The more difficult material was characterized by a technical, unfamiliar vocabulary and complex sentence structure.[1]

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[1] Robert Brown, "Vocabularies in History and Reading Textbooks," Bulletin of the Department of Elementary School Principals, (X, No. 3, 1931), pp. 408-411, quoted from Sloan, p. 80.

[2] Edward L. Thorndike, A Teacher's Word Book of 20,000 Words, (New York: Teachers College, Columbia University, 1932).

That same year Stoddard [2] reported that Ojemann, at the University of Iowa, had studied the reading difficulty of material prepared for adults. He used a test, prepared from sixteen passages of about five hundred words each taken from magazines, to determine the extent to which the readers comprehended the passages after they had read them. The factors which seemed to be important in determining readability were: (1) the number of simple sentences; (2) the number of prepositional phrases; and (3) six vocabulary factors. The best of these six vocabulary factors appeared to be the difficulty of the words as determined by the Thorndike word-list frequency. He also found that difficult passages tended to discuss abstract things; the easy passages discussed concrete experiences. However, he did not develop a formula to determine readability. Three aspects of Ojemann's study were important. These were: (1) the investigation was the first to deal with materials prepared for adults; (2) the material was graded by means of comprehension questions; and (3) special consideration was given to qualitative elements.[1] In this way new variables were being introduced to readability studies.

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[1] Howard Y. McClusky, "A Quantitative Analysis of the Difficulty of Reading Materials," Journal of Educational Research, (XXVIII, December, 1934), pp. 276-282.

[2] George D. Stoddard, "The Reading Ability of Parents and Factors Associated with Reading Difficulty of Parent Educational Materials," Researches in Parent Education, II (Iowa City: University of Iowa, 1934), pp. 1-19, quoted from Sloan, pp. 30-31.

A few months after Stoddard's work telling about Ojemann's study was published, Dale and Tyler undertook a similar problem. This study investigated materials prepared for adults with limited reading ability. They also used a reading-comprehension examination to determine the reading level of those tested. The three factors which they found were most significant were: (1) the number of different hard, non-technical words; (2) the number of different technical words; and (3) the number of indeterminate clauses. These three factors were combined into an equation which could be used to predict the proportion of adults of limited reading ability who might be able to comprehend the material prepared for them.[1]

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[1] Ibid.

In 1935 Gray and Leary made an effort to improve the readability formulas for determining the difficulty of reading matter for children and adults. Gray and Leary selected forty-eight samples of about one hundred words each from books, magazines, and newspapers often read by adults. From these selections they prepared an examination, to be used in determining the reading comprehension of each participant in the study, on each passage. The reading difficulty of each sample passage was the average of the scores made by the adults who took part.[2]

Of the eighty-two factors, with which they started, it was found that five factors could determine reading difficulty as accurately as could the total. These factors were:

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[1] Edgar Dale and Ralph W. Tyler, "A Study of the Factors Influencing the Difficulty of Reading Materials for Adults of Limited Reading Ability," Library Quarterly, (IV, July, 1934), pp. 384-412.

[2] William S. Gray and Bernice E. Leary, What Makes A Book Readable (Chicago: The University of Chicago Press, 1935), p. 138.

(1) the number of different hard words; (2) the number of first-, second-, and third-person pronouns; (3) the percentage of difficult words; (4) the average sentence length in words; and (5) the number of prepositional phrases.[1]

A valuable part of this study was related to the analysis of factors in relation to poor and good readers. Vocabulary measure was the most significant factor for the poorest readers; for the best readers, sentence length and structure was the most significant.[2] This study was one of the first to make a fairly clear distinction between those factors which tended to contribute to the reading difficulty for people who read with different degrees of ability.

These three studies by Ojeman, Dale and Tyler, and Gray and Leary represent the first concerted effort made to study the readability of materials prepared for adults.

During the same year another formula for determining the vocabulary difficulty of textbooks was devised by Lewerenz. The difficulty of a textbook's vocabulary was calculated using such elements as diversity, difficulty, and interest. It was done using a list of common English words prepared by Lewerenz. A sample of one thousand continuous words was used for an analysis of a book. The following variables were used in the vocabulary tabulations: (1) the number of words appearing in the five hundred common words (of Lewerenz); (2) the number of uncommon words; and (3) the total number of words. A method was presented for translating vocabulary difficulty into grade placement.[1]

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[1] Ibid., p. 138.

[2] Ibid., pp. 115-116.

Also in 1935, Gates presented his list of 1,181 words which were familiar to children in the primary grades.[2]

That same year Yoakam devised his readability formula after studying the Thorndike frequency ratings of words in a complete series of readers. Based upon this study, Yoakam felt that such ratings could be a factor in determining reading difficulty. A careful inspection of the material revealed that much of it consisted of words with frequency ratings of one, two, three, and that in each unit or page of reading the number of words with ratings of four and above were relatively few. The use of the frequency ratings of these infrequent words to measure the difficulty of reading material was the basis upon which the formula was developed. A scale was prepared which indicated that the per unit number of words of high frequency rating increased with the difficulty of the material.[1]

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[1] Alfred S. Lewerenz, "A Vocabulary Grade Placement Formula," Journal of Experimental Education, (III, March, 1935), p. 236.

[2] Arthur I. Gates, A Reading Vocabulary for Primary Grades (New York: Teachers College, Columbia University, 1935).

The following year Engleman conducted a study using passages from textbooks and supplementary books. Each passage was written in two styles, that is: narrative and conversational. Vocabulary, facts, and sentence structure were the same in both versions. The results of the study showed no significant difference affecting comprehension between the two styles although the conversational version seemed to be the preferred version. This would indicate that conversational style may have a useful effect when considering book readability.[2]

Also in 1936, Burk studied the effect on readability of direct and indirect conversation. The study showed that children prefer stories containing direct conversation and that the average comprehension was somewhat greater for these stories.

In 1937 Hockett and Neeley made a study of the developmental design of the vocabulary of twenty-eight first readers.

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[1] Gerald A. Yoakam, Basal Reading Instruction (New York: McGraw-Hill Book Company, Inc., 1935).

[2] Finis E. Engleman, "The Relative Merits of Two Forms of Discourse When Applied to Children's Factual Content Reading Material," Journal of Educational Research, (XXIX, March, 1936), pp. 524-531.

[3] Cassie Burk, "A Study of the Influence of Some Factors in Style of Composition on the Interest, Comprehension, and Rate of Reading of Fourth Grade Pupils," Journal of Experimental Education, (IV, June, 1936), pp. 303-352.

They found that while the situation was still almost as bad as it had been fifteen years earlier, there were some signs of improvement.[1] It was therefore quite evident that the articulation of textbooks was still a major problem.

In 1928 Washburne and Vogel developed a readability formula which could be used for grades four through nine. During the intervening ten years they had turned their attention toward the development of a scale that could be used in grades one through three. In their research they asked experienced primary grade teachers to submit lists of both easy and hard books, which had been tried out with children during the previous two years. These books were then tested by using them with children.[2]

As a result of this study two changes were made in the old formula. Prepositional phrases were no longer counted. The measure of commonness of vocabulary was changed. A three-factor formula was developed. It was based on: (1) the number of different words found in the 1,000 word sample; (2) the number of different words not among the 1,500 most frequently used words in the Thorndike word list; and (3) the number of simple sentences found in a systematic sampling of seventy-five sentences.[1]

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[1] John A. Hockett and N. Glen Neeley, "The Vocabularies of Twenty-Eight First Readers," Elementary School Journal, (XXXVII, January, 1937), pp. 344-352.

[2] Carleton W. Washburne and Mabel V. Morphett, "Grade Placement of Children's Books," Elementary School Journal, (XXXVII, January, 1938), pp. 355-364.

In the course of their research, in 1938 Durrell and Sullivan counted the words in basal readers and social science textbooks used by the fourth, fifth, and sixth grades.[2] That same year Hockett determined the basic vocabulary of one hundred and sixty-six reading books ranging from pre-primers to fourth grade.[3] Thus, research continued in subject matter areas.

Also in 1938, DeLong counted the number of difficult words in primary reading material. The purpose of his study was to devise a scheme which would retain the mastery of a basic vocabulary, but would eliminate the needless rereading of many stories. Every book was placed at a specific level in relation to the repetition of words in each book so that there would be a proper sequence of matter in terms of the number of new words to be introduced from book to book.[4]

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[1] _Ibid_., pp. 350-360.

[2] D. D. Durrell and Helen Sullivan, "Vocabulary Instruction in the Intermediate Grades," _Elementary English_ Review, (XV, April, 1938), pp. 138-145.

[3] John A. Hockett, _The Vocabulary Contents of Elementary School Subjects_ (Sacramento: California State Printing Office, 1938), quoted from Haffner, p. 6.

[4] Vaughn R. DeLong, "Primary Promotion by Reading Levels," _Elementary School Journal_, (XXXVIII, May, 1938), pp. 663-671.

That year also saw Rudisill make a vocabulary analysis of twenty-six pre-primers and seventeen primers to determine in which order they should be read. She found that certain pre-primers and primers designed to be used in sequence did not normally go together as well as certain other combinations of pre-primers and primers. Rudisill concluded that the number of pre-primers which should be read depended on the percentage of the vocabulary of a primer contained in each pre-primer and on the degree of identity between the vocabularies of the various pre-primers. She stressed the sequence in which these books were read was an important factor in determining a child's successful growth in beginning reading.[1] As a result of these studies there was a growth in knowledge concerning the articulation of books from grade to grade.

Strang studied the opinions of high school and college students concerning what makes a book readable. The students considered style to be the most important factor, content next, format third, and organization last.[2] It is interesting to note that vocabulary was not included as an important factor.

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[1] Mabel Rudisill, "Selection of Preprimers and Primers-A Vocabulary Analysis, Part II," Elementary School Journal, (XXXVIII, June, 1938), pp. 767-775.

[2] Ruth Strang, "Estimating the Difficulty of High School and College Material," Practical Values of Educational Research (Washington: American Educational Research Association, 1938), pp. 50-51, quoted from Haffner, p. 8.

Lanslittle in his 1939 report of his analysis of four history textbooks for "abstractions without concretes" and for "generalities" wrote:

> Whatever other means have been developed for presenting history to students, the printed page is still the foremost, and in all likelihood it will continue to be the foremost. But the textbook, instead of serving as the major aid in the learning and teaching of history, is in fact the main source of difficulty.[1]

In terms of tabulation of the words, which were selected subjectively, he discovered that over fifty per cent of the terms or collocations used were obscure, since many of the words were beyond the comprehension of the pupils and were presented in the written context in such a way as to confuse the reader. The investigator felt that the results of the study were on the conservative side and that the textbooks contained more vague and obscure concepts than actually were reported in his study.[2]

In a work reported in 1939 by Irving Lorge, Morris and Holversen at the Readability Laboratory of Teachers

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[1] F. C. Lanslittle, "How General and Vague Are World Histories?" Social Education, (III, November, 1939), p. 547.

[2] *Ibid.*, pp. 547-550.

College, Columbia University, attacked the vocabulary problem from a different angle. They developed an "Idea Analysis Technique" for estimating the difficulty of reading passages. Their variables were based on the kinds of words used in a passage. Their variables were: (1) the simplest word labels representing fundamental experiences in the life of a people in a given culture; (2) words also learned early in life which differ from the first classification in being word-ideas which are localisms; (3) words signifying concrete ideas; and (4) words signifying abstractness, quality, and states of mind.[1] While this was one of the first attempts to consider the qualitative role of certain aspects of vocabulary analysis, this readability approach did not prove to be too effective.

During this same year Yoakam's tentative scale was used as the basis of a study by Stadtlander to determine the validity of his assumption. Scaled materials consisting of selections from fiction, history, science, aviation, geography, and legends were compared. The scale consisted of one hundred-word selections ranging from zero, that is having no words above the number four on Thorndike's list, to a selection containing words with serial number totaling one hundred. Twenty multiple-choice type of items were prepared to measure comprehension of implied facts, stated facts, central thought, and vocabulary meaning of each unit of the scale. The scale was then tested on 2,763 children in grades four through six who had been given the New Stanford Reading Test, Form W. The children's scores on the scale were then compared with their grade equivalents on the New Stanford Reading Achievement Test and the scale values determined in terms of the average number of children of known reading achievement who reached a certain score on the scale as determined by the comprehension test.[1]

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[1] Irving Lorge, "Predicting Reading Difficulty of Selections for Children," Elementary English Review, (XVI, October, 1939), pp. 229-233.

Research tends to advance on many fronts simultaneously, and in 1940 Gray and Leary made a survey of publishers, librarians, teachers, and adult readers to determine what they thought the factors in readability were. The findings reported by Leary were that this group of people indicated that style, content, format, and organization were the factors in readability.[2] Again, little attention was paid to vocabulary.

In 1941 Spache expressed concern over vocabulary control for primers and supplementary primers. He was concerned about vocabulary factor norms for such classifications as total number of words, number of different words, average word repetition, number of new words per page, percentage of words repeated six or more times, percentage of pre-primer words, percentage of standard vocabulary found in certain well known word lists, number of new words introduced, and the percentage of vocabulary that was unknown.[1]

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[1] Elizabeth Stadtlander, "A Scale for Determining and Evaluating Reading Materials for the Middle Grades," (unpublished doctoral dissertation, University of Pittsburgh, 1939), pp. 1-96, Quoted from Sloan, p. 47.

[2] Bernice E. Leary, "Difficulties in Reading Material," Reading in General Education (Washington: American Council on Education, 1940), p. 280, Quoted from Haffner, p. 8.

Three additional studies were made in 1941. Cole made a frequency count of the characteristic words used in textbooks.[2] Stone issued a report on words used in twenty readers from pre-primer to the third grade.[3] Thorndike, in collaboration with Lorge, completed a 30,000 word list.[4] These studies provided a better understanding of the extent and kind of vocabulary that was used in textbooks.

One of the more unusual studies made in 1941 was that of Thorndike. He used the Lorge formula to determine the reading difficulty of several comic books, and found that they were written at about the fifth- and sixth-grade levels. While they contained a great number of slang words, they were generally written with standard, average English words. Thorndike concluded that one of the reasons these books appealed to so many children could be the fact that they were written at an easy reading level for many upper-elementary children.[1]

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[1] George Spache, "Problems in Primary Book Selection," Part III, "Selection of Primers and Supplementary Primers," Elementary English Review, (XVIII, April, 1941), pp. 139-148.

[2] Luella Cole, The Teacher's Handbook of Technical Vocabulary (Bloomington: Public School Publishing Company, 1941).

[3] C. R. Stone, Stone's Graded Vocabulary for Primary Reading (St. Louis: Webster Publishing Company, 1941).

[4] Edward L. Thorndike and Irving Lorge, The Teacher's Wordbook of 30,000 Words (New York: Teachers College, Columbia University, 1941).

Thorndike also noted that the comic books provided a substantial amount of reading experience for children of both elementary and junior high school age. For the educator who is interested in working with the child "as he is," comic books could be used as supplementary readers that could lead the child from his present status to higher and better things.[2]

One of the problems that faced workers in readability was that of determining the readability of materials for the average adult reader. After experimenting with various reading formulas, in 1943 Flesch came to the conclusion that these formulas were good only up to a certain level of difficulty. This point seemed to be that of popular adult reading matter. He did, however, find one element which was equally significant for the best as well as the poorest readers. This was sentence length. From the work of Morris and Holversen, he also got the idea that difficult material was characterized by abstract concepts. In order to consider this factor, Flesch used affixed morphemes to determine the abstractness of a passage.[1]

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[1] Robert L. Thorndike, "Words and the Comics," Journal of Experimental Education, (X, December, 1941), pp. 110-113.

[2] Ibid.

For his criterion of difficulty of adult reading matter Flesch used a scale of widely read magazines. These he divided into five levels of difficulty. Level A, the easy reading level, contained such magazines as Modern Screen and True Confessions. Level C, the average level, was represented by Reader's Digest. Level E, the difficult level, contained Yale Review and The American Scholar.

Randomly selected recent issues at each level of difficulty were tested by sampling three passages of one hundred words each in five articles in each issue. In relating the variables used by Lorge (number of hard words, average sentence length, and the number of prepositional phrases), and Flesch's two measures of abstraction (abstract words and affixed morphemes), he found that his two-word factors showed the closest relationship to magazine levels.

The formula which Flesch developed from this study included the following elements: (1) average sentence length in words; (2) number of affixed morphemes; and (3) the number of personal references. While this formula was originally devised to be used in measuring the reading difficulty of popular matter, it was soon adjusted to predict for grade levels. This formula proved to be a better predictor for the secondary grades than did the formulas which were developed from the McCall-Crabbs passages.[1]

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[1] Rudolph Flesch, Marks of Readable Style, Contributions to Education, No. 897, (New York: Teachers College, Columbia University, 1943), p. 34.

The Lorge formula, developed in 1944, was an easy means of judging the readability of either spoken or written passages. In developing this formula, Lorge used the 376 selections included in the McCall-Crabbs Standard Test Lessons in Reading, Books II, III, IV, and V.[2] Each of these passages was standardized on the basis of the number of questions correctly answered by children in terms of scores on the Thorndike-McCall Reading Scale. The questions were designed to measure specific detail, general import, appreciation, knowledge of vocabulary, and comprehension.

The readability index was an estimate of the reading grade level at which the average school child would be able to answer completely and correctly about three-fourths of the questions concerning detail, appreciation, vocabulary, import and concept.[1]

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[1] Ibid.

[2] W. A. McCall and Lelah Crabbs, Standard Test Lessons in Reading (New York: Bureau of Publications, Teachers College, Columbia University, 1929).

The predictors studied by Lorge were the same ones used by Gray and Leary: (1) a weighted-score vocabulary based on Thorndike's Teacher's Word List of 20,000 Words; (2) percentage of elemental words; (3) percentage of localisms; (4) percentage of word-labels; and (5) percentage of abstract word-labels.[2]

In 1945 Yoakam made a study of the changes in readability levels of reading books published between 1930 and 1945. While grade placement by the publishers was more in accordance with measured readability, the publishers still tended to underestimate the difficulty of readers.[3]

In 1946 Porch made a study of the reading difficulty of the adopted textbooks in Alabama. Among the textbooks analyzed were four social studies textbooks, one for each grade, three through six.

Using the Lorge readability formula Porch found that the grade placement of the third-grade social studies text was 1.13 grades higher than it should have been for use in that grade. The fourth- and fifth-grade textbooks were properly assigned, in terms of readability, by the publishers. The sixth-grade social studies textbook rated lower than the grade level to which it was assigned. However, portions of these textbooks had readability levels higher than the grade levels for which they were written.[1]

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[1] Irving Lorge, "Predicting Readability," Teachers College Record, (XLV, March, 1944), pp. 404-419.

[2] Ibid.

[3] Gerald A. Yoakam, "The Reading Difficulty of School Textbooks," Elementary English Review, (XXII, December, 1945), pp. 305-306.

Porch found that three of these four textbooks began at levels of readability too high for the beginning of the grades to which they were assigned by the publishers.

In 1948 Flesch revised his formula. The affix count was changed to a syllable count. This was combined with a sentence length factor. The personal reference element was dropped and a new formula was developed for determining human interest.[2]

That same year Dale and Chall concluded that if all of the counts of vocabulary load were interrelated, a simpler method would be preferable to a less exact or a more complex method. From the evidence available they concluded that there was merit in using a word list to measure vocabulary load.

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[1] Avis Kilgore Porch, "Reading Difficulty of Adopted Textbooks," (unpublished Master's thesis, Alabama Polytechnic Institute, 1946), pp. 8-24, quoted from Sloan, p. 82.

[2] Rudolph Flesch, "A New Readability Yardstick," Journal of Applied Psychology, (XXXII, June, 1948), pp. 221-233.

The Dale list of 769 words was too restrictive; therefore, this basic word list was expanded into a larger one. The final list was one of 3,000 words well known to fourth graders.

The McCall-Crabbs Standard Test Lessons in Reading were used as the measure in developing the formula. Lorge made available the data he had used in deriving his formula from the McCall-Crabbs tests. Dale and Chall used for their criterion the grade-level score equivalent for a group who could get half of the questions right on each passage of the test. It was found that the highest correlation to the criterion was the relative number of words outside the Dale list of 3,000 words. Another good correlation was that with sentence length,[1] Dale and Chall had good results with their tests of their formula.

Chall and Dial also tested the formula using it to test the reading difficulty of newscasts by means of an examination on the facts and ideas presented in the newscasts.[2]

In 1948 Yoakam issued a revision of his previous formula. He considered that vocabulary load used in conjunction with the average number of words per page to be a sufficient sensitive index of readability.[1]

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[1] Edgar Dale and Jeanne S. Chall, "A Formula for Predicting Readability," Educational Research Bulletin, (XXVII, January, 1948), pp. 15-18.

[2] Jeanne S. Chall and Harold E. Dial, "Predicting Listeners' Understanding and Interest in Newscasts," Educational Research Bulletin, (XXVII, September 15, 1948), pp. 141-153, 168.

In spite of the revisions which Flesch had made in his formula, it was still rather difficult to use. In 1951 Farr, Jenkins, and Peterson simplified the Flesch formula by counting the number of one-syllable words per one hundred words.[2]

Although a 1952 dissertation by Smith was designed primarily for comparing the grade placement of the Dale-Chall, Lorge, and Yoakam formulas, it gave an analysis of the average difficulty of certain social studies textbooks and related materials used in the fourth grade. Her study showed geographies to have an average grade placement of 4.91. The average grade placement of histories was 4.61, a little lower than geographies. Workbooks were the most difficult of all, with a grade placement of 5.20. Unified courses in My Weekly Reader were 5.07 and 5.13 respectively.[3]

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[1] Gerald A. Yoakam, Basal Reading Instruction (New York: McGraw-Hill Book Company, Inc., 1955), pp. 329-340.

[2] James N. Farr, James J. Jenkins, and Donald G. Peterson, "Simplification of Flesch Reading Ease Formula," Journal of Applied Psychology, (XXXV, October, 1951), pp. 333-337.

[3] Ruth Smith, "An Investigation of the Readability of Recently Published History and Geography Textbooks and Related Materials for the Fourth Grade," (unpublished Doctoral dissertation, University of Pittsburgh, 1952), quoted from Sloan, p. 83.

In 1953 Harrison investigated the extent to which arithmetical terminology of the problems presented for practice and solution in arithmetic textbooks was a source of semantic difficulty. She found that the group of arithmetic words was significantly larger and more varied than had been expected. Numerous terms, notably abbreviations and hyphenated words, were found to be sources of confusion in the understanding of concepts. The context of problems did not always tend to clarify meanings for the pupils.[1]

During this same year Swanson and Fox made several tests of the Dale-Chall formula. They achieved good results with their tests of this formula.[2] A new line of research was thus in progress. The readability formulas which had been developed were now being tested and refined.

A 1953 study by Peterson was concerned with two questions: (1) How well do students comprehend textbook material? (2) What difficulties do they encounter in reading? Comprehension measurement was limited to five reading categories in social studies textbooks. They were: (1) understanding words in context; (2) grasping meaning; (3) noting relationships of specific details; (4) drawing correct inferences; and (5) integrating the expressed ideas with experiences.[1]

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[1] Irene G. Harrison, "Survey of Meanings of Words and Signs in Two Arithmetic Textbook Series," (unpublished Doctoral dissertation, Columbia University, No. 6631, 1953), quoted from Sloan, p. 75.

[2] Charles E. Swanson and Harland G. Fox, "Validity of Readability Formulas," Journal of Applied Psychology, (XXXVII, April, 1953), pp. 114-118.

Two one-thousand-word selections were used for examination and rewriting. Students were tested over the first passages as they were originally written. They were then examined over the material as rewritten according to certain suggested principles.

Peterson suggested that reading comprehension and understanding of written materials could be improved greatly if writers would include only the essential technical words whose relationship to the context could be made evident. New words should be repeated in a variety of ways to familiarize the reader with the word formation. Colorful, active, familiar words and exact definitions should be used to explain new ideas.[2]

In 1955 Morton discussed certain problems associated with the writing and preparation of textbooks. Rather than merely concluding that most textbooks in arithmetic used words which were too difficult and sentences which were too long, he offered several specific suggestions. He indicated that there was a certain minimum of technical words essential to the development of arithmetical ideas and concepts but that they were introduced too early in the child's experience. Such words as addend, minuend, subtrahend, and multiplicand should not appear in third-grade arithmetic books in his opinion.[1]

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[1] Eleanor Ruth Peterson, "Aspects of Readability in the Social Studies," (unpublished Doctoral dissertation, Columbia University, No. 6683, 1953), quoted from Sloan, p. 83.

[2] Ibid.

Morton's view is not one that is completely accepted. Bruner offered a different proposition, "any subject can be taught effectively in some intellectually honest form to any child at any stage of development."[2]

Morton also stated that a writer should avoid making frequent use of unknown terms and phrases without definition or explanation. The use of any new terms should always be accompanied by an explanation. He also listed as factors which added to reading difficulty explanatory statements which were vague, inadequate, or incomplete; the use of familiar words in unfamiliar ways; and statements which were misleading or incorrect or that might lead the pupil to wrong conclusions.[3] He concluded: "The main challenge of arithmetic should be arithmetic itself and not the language in which arithmetical ideas are expressed."[1]

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[1] R. L. Morton, "Language and Meaning in Arithmetic," Educational Research Bulletin, (XXXIV, November 9, 1955), pp. 197-204.

[2] Jerome S. Bruner, The Process of Education (Cambridge: Harvard University Press, 1960), p. 33.

[3] Morton, pp. 197-204.

In 1955 Smiley found that very little effort had been given to the selection and uses of types of symbols used in music texts. There was wide variation within each of the textbooks and between the textbooks analyzed. Only one of the four books she evaluated presented a planned use of terms whose usage was explained. She came to the conclusion that the data did not reveal vocabulary planning in the textbooks.[2]

That same year Walchak found that there had been a definite improvement in the readability of textbooks published for the fourth grade level. The same thing did not seem to be true, however, for the fifth- and sixth-grade levels.[3]

Also in 1955, Yoakam presented another revision of his textbook.[1]

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[1] Ibid., p. 204.

[2] Edra Meads Smiley, "A Study of the Musical Configurations, Symbols, Terms and Words Found in Basic Music Texts at the Fourth Grade Level," (unpublished Doctoral dissertation, Indiana University, 1955), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XV, September, 1955, Abstract No. 13, 232, (Ann Arbor: University Microfilms, 1955), p. 1629.

[3] Frank Adam Walchak, "An Appraisal of the Trend of Readability of Basic Reader Series for Intermediate Grades," (unpublished Doctoral dissertation, University of Pittsburgh, 1935), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microfilm, XV, October, 1955, Abstract No. 13,901, (Ann Arbor: University Microfilms, 1955), pp. 1762-1763.

In 1945 Edgerton used the Washburne formula to analyze the reading difficulty of several encyclopedias. He found that he could rank the reading difficulty of these works in the following way: Britannica Junior, Compton's, and World Book. The medians for these three sets of books falling in grades nine, ten and eleven respectively. All of these works appeared to be too difficult for all except the most exceptional readers in the elementary grades.[2]

During the next ten years the publishers of these encyclopedias made progress in reducing the vocabulary load and shortening the sentence length of their books. The average reading levels were reduced to grades six, seven, and eight in World Book, Britannica Junior, and Compton's, respectively. As a result, most of the articles in World Book, and Britannica Junior were then within the reading comprehension of many elementary school children.[3]

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[1] Gerald A. Yoakam, Basal Reading Instruction (New York: McGraw-Hill Book Company, Inc., 1955).

[2] Ronald Edgerton, "How Difficult Are Children's Encyclopedias?" Elementary School Journal, (XLV, April, 1945), pp. 461-463.

[3] Ronald Edgerton, "How Difficult Are Children's Encyclopedias?--A Second Report," Elementary School Journal, (LV, December, 1954), pp. 219-225.

Also in 1955, Covell used Test 5 of the Iowa Tests of Educational Development to determine the ability of students to interpret reading materials in the social studies. He found that good social studies readers possessed a broad and deep vocabulary of the technical language used in social studies and, conversely, the technical vocabulary of the poor social studies reader was weak and limited in breadth and depth. The good social studies readers had a rich and accurate understanding of time and place concepts. The poor readers in social studies possessed very vague and poorly developed concepts involving time and place.

Also, good social studies readers demonstrated a pattern of strength in general and technical vocabulary, and sentence and paragraph comprehension. On the other hand, the poor readers were weak in all of these areas. It was felt that this study demonstrated that the style of writing, sentence and paragraph structure, and vocabulary presented real obstacles to poor readers.[1]

In 1956 Hollingsworth evaluated the Ohio Reading Circle books for readability. These are books written for children. Hollingsworth's data indicated that literature written for children in the 1940's and 1950's was no more difficult than materials written for children during the 1920's and 1930's.

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[1] Harold Manfred Covell, "A Study of the Characteristics of Good and Poor Readers of Social Studies Materials at the Eleventh Grade Level," (unpublished Doctoral dissertation, The Florida State University, 1955), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XV, September, 1955, Abstract No. 13,055, (Ann Arbor: University Microfilms, 1955), pp. 1570-1571.

His conclusion was that the Ohio Reading Circle Books for grades seven and eight were reasonably well placed. However, there appeared to be too few readable books selected for grades four, five, and six. Hollingsworth recommended that some objective criteria, and particularly vocabulary items, be used in conjunction with expert opinion in selecting and placing children's literature on graded lists.[1]

In 1957 Tribe[2] based a study on Rinsland's[3] A Basic Vocabulary of Elementary School Children. In his effort to develop a readability formula that would predict the grade level of elementary reading material, Tribe also used the

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[1] Glen Howard Hollingsworth, "The Readability of Ohio Reading Circle Books," (unpublished Doctoral dissertation, University of Pittsburgh, 1956), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XVI, December, 1956, Abstract No. 18,236, (Ann Arbor: University Microfilms, 1956), pp. 2348-2349.

[2] Edward B. Tribe, "A Readability Formula for the Elementary School Based upon the Rinsland Vocabulary," (unpublished Doctoral dissertation, The University of Oklahoma), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microfilm, XVII, April, 1957, Abstract No. 20,569, (Ann Arbor: University Microfilms, 1957), pp. 788-789.

[3] Henry D. Rinsland, A Basic Vocabulary of Elementary School Children (New York: The Macmillan Company, 1945).

McCall-Crabbs Standard Test Lessons in Reading. Factors which he considered were: (1) the average sentence length; (2) percentage of different words; (3) percentage of prepositions; (4) percentage of simple sentences; (5) percentage of different words not on the basic word list, which was derived from Rinsland's word list; (6) percentage of polysyllabic words; and (7) percentage of different words on the basic list. His final two-factor formula used the average sentence length and the percentage of different words not on the basic word list.[1]

In Research in the Three R's, which was published in 1958, Hunnicutt and Iverson[2] described the readability formula of George Spache. Spache's concern was with the reading difficulty of children in grades below the fourth grade. The formula he developed was a two-factor formula based on the average sentence length in words and the Dale list of 769 words. Words which were not included in this list were considered to be hard words for primary children.

Spache used 224 samples of one hundred words selected from one hundred and fifty-two books in common use in the first three grades. These textbooks were used primarily for basal reading instruction, except for twenty-three science, health, and social studies textbooks. A grade placement was assigned to each book according to the grade level at which it was used. Sentence length and the percentage of hard words were the factors used in a formula to predict the grade level of these primary textbooks.[1]

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[1] Tribe.

[2] C. W. Hunnicutt and William J. Iverson, Research in the Three R's (New York: Harper and Brothers, 1958), pp. 177-179.

In 1958 Wyatt and Ridgeway reported a study made by Ridgeway in connection with his master's thesis. The investigator used the Dale-Chall readability formula to test nine state-adopted social studies textbooks in Kansas. Five of these books were used in grades four, five and six.[2]

Twenty samples were taken from each of the books to be tested. Of the elementary social studies textbooks analyzed, all were written at the grade level to which they were assigned by the publishers. Even so, there was considerable variation in the levels of reading difficulty within each book. The investigator was as much concerned with the range of reading level as he was with the average reading level for a textbook.

In most of the social studies textbooks written for use in the upper elementary grades Ridgeway found passages which were written at least two grades higher than the grades for which they were intended. In contrast, the fourth- and fifth-grade social studies textbooks had certain passages below the grades to which they were assigned. The Dale-Chall formula does not give a grade placement score below 4.0. However, the one fourth-grade book analyzed had at least one sample below the 4.0 level; the two fifth-grade textbooks also had samples at or below the 4.0 level; and the sixth-grade social studies texts had samples at the 4.0 level.[1]

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[1] Ibid.

[2] Nita M. Wyatt and Robert W. Ridgeway, "A Study of the Readability of Selected Social Studies Materials," University of Kansas Bulletin of Education, (XII, No. 3, 1958), pp. 100-105, quoted from Sloan, pp. 85-88.

Wyatt and Ridgeway also reported a study made by Walker in 1955. In this research the reading difficulty of a particular fifth-grade social studies textbook was compared with the actual reading ability of sixty-five fifth-grade pupils in Kansas. In her study it was demonstrated that fourteen per cent of the pupils tested would not have been able to read with understanding this particular textbook. This was indicated by the scores they made on the Silent Reading Comprehension Test of the Iowa Every Pupil Tests of Basic Skills. Approximately eighty-five per cent of the pupils tested would have encountered some difficulty in reading certain portions of this book. The most difficult sample of this textbook had a grade level of reading difficulty of 8.0. Only fourteen per cent of the students would have had no difficulty in comprehending the written material in this textbook.[1]

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[1] *Ibid*.

Wyatt and Ridgeway concluded that even though a textbook might have a grade average at the grade level to which it was assigned, the wide range in reading difficulty found indicated that graded supplementary materials should be available for pupils with different levels of reading ability. In addition they stated:

> The social studies is an area of the curriculum in which the teaching of vocabulary is of prime importance. The difficulty experienced by many pupils in reading social studies materials could be reduced by a conscious effort on the part of the teacher to teach the special vocabulary which contributes to a high level of reading difficulty of these materials.[2]

To facilitate the implementation of this recommendation a bibliography of graded supplementary materials for use with a unit on the North Central States was presented with this study.[3]

In 1959 Sloan determined the readability of social studies textbooks for grades four, five, and six by means of the Dale-Chall formula. Seven series of social studies textbooks were analyzed. Among his findings Sloan found: (1) Writers and/or editors of the social studies textbooks included in the study had made an effort to control the readability of each textbook, since he found that the general grade placement of only one text was more than one grade above or below the grade level to which the textbook was assigned by the publisher; (2) General grade placements in approximately one-half of the social studies textbooks agreed with the grade levels to which the books were assigned by the publishers. Of the general grade placements which were not satisfactory, all but one were within one grade level of the grade to which the textbooks had been assigned. If unsatisfactory, the general grade placements tended to be above grade level rather than below. Of the twenty-one textbooks analyzed, eleven had grade placements which coincided with the grades to which they were assigned by the publishers. Three of these eleven were fourth-grade books; two were fifth-grade books; and six were sixth-grade books. (3) Only one series of social studies textbooks had general grade placements which coincided with the grade level to which each of the three books in the series had been assigned by the publishers.[1]

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[1] Margaret A. Walker, "Remedial Reading Programs at the Junior High School Level," (unpublished manuscript, School of Education, University of Kansas, 1955), 15 pp., quoted by Nita M. Wyatt and Robert W. Ridgeway, "A Study of the Readability of Selected Social Studies Materials," University of Kansas Bulletin of Education, (XII, No. 3, 1958), pp. 101-102, quoted from Sloan, p. 87.

[2] Wyatt and Ridgeway, p. 103.

[3] *Ibid.*, pp. 104-105.

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[1] Fred A. Sloan, Jr., "Readability of Social Studies Textbooks for Grades Four, Five, and Six as Measured by the Dale-Chall Formula," (unpublished Doctoral dissertation, George Peabody College for Teachers, 1959), pp. 306-307.

In another 1959 dissertation Haffner found that in fifth- and sixth-grade social studies, history, and geography textbooks, the readability levels, as determined by the Yoakam formula, and the grade placement indicated by the publisher agreed only for eighteen per cent of the forty-two books examined. Haffner also found an "erratic distribution of these difficult words throughout the textbooks with the greatest vocabulary load usually found in the first half of each book."[1]

This investigator concluded (1) the publisher designated grade level was not always a reliable indicator of the readability level of the textbook and that (2) the textbooks analyzed contained a vocabulary load in excess of what can be expected of children.[2]

The investigation of textbooks by subject matter fields continued and in 1960 Miller[3] compared the reading level of five general shop textbooks used on the ninth-grade level with the reading abilities of ninth-grade industrial arts students. For his study, Miller obtained his data through the application of the Dale-Chall and Flesch formulas. The investigator concluded "The readability ratings assessed by the two formulas were in close agreement; therefore, for all practical purposes either of the formulas would be sufficient to judge the relative difficulty of the general shop textbooks.

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[1] Hyman Haffner, "A Study of Vocabulary Load and Social-Concept Burden of Fifth and Sixth Grade Social Studies, History, and Geography Textbooks," (unpublished Doctoral dissertation, University of Pittsburgh, 1959), p. 71.

[2] *Ibid.*, p. 72.

[3] Wilbur Randolph Miller, "Levels of Readability of General Shop Textbooks Compared with the Reading Abilities of Ninth Grade Industrial Arts Students," (unpublished Doctoral dissertation, University of Missouri, 1960), quoted from *Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform*, XXI, December, 1960, Abstract No. 60-4047, (Ann Arbor: University Microfilms, 1960), p. 1426.

"Certain parts of general shop textbooks could be read by students with sixth-grade reading ability while other parts of these textbooks would demand a reading ability as high as 'college level'"[1]

In 1961 Weaver presented a new reading measurement technique entitled the "cloze" test.

> The problem of this study was to determine if differences existed in the ability of subjects to predict words omitted from language materials intended for oral and written presentation. Tests designed in this fashion have been named "Cloze" Tests.
>
> Two groups of 80 subjects each (Juniors and Seniors at the University of Georgia) were used in this study. The subjects were further sectioned into 16 groups of 10 each and administered 8 "cloze" tests in various orders. The last test given in each instance was the experimental test. The "cloze" tests used were constructed by deleting every tenth word from language passages intended for oral and written presentations, and by deleting every tenth noun or main verb in other language passages intended for oral and written presentation.
>
> One group received "cloze" reading tests and cloze aural tests in a multiple-pass situation.

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[1] *Ibid.*, p. 1426.

> That is, they were allowed as many repetitions of the listening materials as they desired. The other group recieved "cloze" reading tests and "cloze" aural tests in a single-pass situation. They were allowed to hear the aural materials only once.
>
> A 2 X 2 X 4 analysis of variance design was used for the statistical analysis of the data. The multiple-pass and the single-pass situations were analyzed separately.
>
> Although the multiple-pass aural situation increased the predictability of the missing words, the relationships within the two situations were essentially the same. The central finding is that structural meaning, as shown by the predictability of "any-word" cloze, is conveyed significantly better by silent reading while lexical meaning, as shown by the predictability of nouns and main verbs, is conveyed equally well by listening or by silent reading. Whatever advantage allowed the greater predictability of structural meaning in the silent reading situation is in some manner lost in the listening situation.
>
> There are indications that this loss is due to the relatively small context necessary for supplying predictive information in the lexical case in most situations, compared to the relatively larger context needed to supply all the structural meaning available. The fact that large contextual elements can be analyzed only with great difficulty in the listening situation may drive the organism to use the strategy of depending on the small context in both structural and lexical situations, thereby losing the structural meaning which depends upon large context.[1]

A new approach to vocabulary study was developed when in 1963 Howards measured children's understanding, at different age levels, of various meanings of selected high-frequency, mono-syllabic, multiple-meaning words which appear in scientific word lists. The Multiple-Meaning Word Test was devised to determine which meanings of a selected group of multiple-meaning words children in grades four, five, and six knew. The words used on the test all appear on all of the scientific word lists and they are all considered "easy" or familiar words.

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[1] Wendell William Weaver, "An Examination of some Differences in Oral and Written Language Using the Cloze Procedure," (unpublished Doctoral dissertation, University of Georgia, 1961), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXII, May, 1962, Abstract No. 61-6587, (Ann Arbor: University Microfilms, 1962), p. 2702.

The major conclusions of this study were: (1) a developmental pattern is exhibited by children in grades four, five, and six with regard to their knowledge of various meanings of selected high-frequency, mono-syllabic, multiple-meaning words, but this pattern is not necessarily symmetrical; (2) the relative ease or difficulty encountered by a reader is not solely dependent upon the frequency with which such words may appear in reading content, but it is significantly affected by which meanings of these "easy" words the reader knows; (3) scientific word lists and readability word lists utilized in grading reading material in terms of grade level equivalents need to allow for this element of semantic variation; in short, what these word lists have been classifying as "easy" or familiar may indeed be extremely difficult for certain readers depending on the particular context; (4) the individual who knows several different meanings of words (depth dimension of vocabulary) is almost certain to know many different words (breadth dimension).[1]

In 1964 Neel used much the same approach to vocabulary testing that Howards had used the year before. Neel's study was concerned with the measurement of children's knowledge of multiple-meaning words. The study required a free-writing response by fourth-grade children of the schools in Napa County to a list of 180 words with multiple meanings such as well and back.[2]

The papers were scored by identifying the closest shade of meaning for each key word according to Webster's New World Dictionary of American Language and by then counting the number of different meanings each subject had given for all 18 words. The number of times each word was used in each of its different meanings was tallied on a master list. This tally revealed the meaning most frequently used and least frequently used for each of the 180 words.[3]

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[1] Melvin Howards, "Measuring Children's Understanding of Selected Multiple-Meaning Words as it Relates to Scientific Word Lists," (unpublished Doctoral dissertation, New York University, 1963), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXVI, August, 1965, Abstract No. 63-6665, (Ann Arbor: University Microfilms, 1965), pp. 905-906.

[2] Virginia McCoy Neel, "Measurement of Fourth Grade Children's Knowledge of Words With Multiple Meanings," (unpublished Doctoral dissertation, University of California, Berkeley, 1964), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXV, September, 1964, Abstract No. 64-8521, (Ann Arbor: University Microfilms, 1964), p. 1664.

[3] *Ibid.*, p. 1664.

This same year another test of the cloze procedure was made by Greene, this time with adults. However, this dissertation was primarily concerned with learning more things about the cloze technique and various variations of it. As a result the findings did not appear to have much application to the prediction of reading difficulty. Further testing of the cloze technique seemed to be indicated.[1]

The cloze technique was applied to materials for the primary grades by Gallant in a study also reported in 1964.

> This study dealt with two related problems, (1) the reliability and validity of cloze tests as a measure of reading comprehension for pupils in the primary grades, and (2) the effect of increased sentence length on the readability of materials designed for use with these pupils.
>
> The procedure for problem one involved the rewriting of the paragraph section of the Metropolitan Reading Achievement Tests for grades one, two, and three. A modified form of cloze procedure was devised for use with grade one. In regular cloze procedure, every fifth word is replaced by a blank line on which the subject writes his response. In the revised form used with grade one, three multiple-choice responses were provided for every deleted fifth word in the passages.
>
> The cloze test and a comparable form of the Metropolitan Test were administered to 273 pupils. Pearson product-moment correlation was used to determine if the rankings of pupils on the cloze test corresponded with the rankings on the

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[1] Frank Pieerepont Greene, "A Modified Cloze Procedure for Assessing Adult Reading Comprehension," (unpublished Doctoral dissertation, The University of Michigan, 1964), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXV, March, 1965, abstract No. 65-5308, (Ann Arbor: University Microfilms, 1965), p. 5734.

standardized achievement test. Within each grade level, the corelation obtained for the boys was compared to that of the girls. A two-way analysis of variance was used to test the significance of the differences between the cloze test scores when the pupils within each group were subdivided by sex and classified by tested reading achievement levels. The analysis was calculated for second and third grade scores, each grade level handled as a separate group.

For the second problem, two sets of passages were written, each consisting of five levels of reading difficulty as measured by the Spache readability formula. The revised passages were similar to the basal passages in number of words per passage and difficulty of vocabulary. Sentence length had been increased in the revised passages so that the Spache readability level ranged from three months to one year higher than that of the basal passages. Cloze tests over both sets of passages were administered to 273 pupils. Differences in mean cloze performance were tested for significance of each grade level.

Findings were as follows: the correlations between the cloze tests and the standardized reading tests for each grade in total and for each grade subdivided by sex were significant. The analysis of variance corroborated the validity of cloze scores as a measure of reading comprehension. The effect of sex on cloze test performance was shown to be significant for the second and third grade scores. Although the relationship of cloze performance to the standardized test scores was essentially the same for both sexes, the analysis indicated that it was taking place at a higher level for girls. The readability coefficients for the cloze tests ranged from .90 to .97.

Differences in mean cloze test performance for the basal and revised passages were significant at the .01 level for both sexes and the total groups in grades one and two.

At the third grade level the difference between the means was not significant for the boys on either set of scores, exact or substitute. The difference was significant at the .05 level for the exact scores of the girls and the total exact scores.

It was concluded that cloze tests were valid and reliable measure of readabilty for the primary

> grades. Increase in sentence length appeared to increase the difficulty level of materials for first and second grade pupils, but this increase did not hold true for all subgroups of grade three.[1]

Another 1965 study of the vocabulary load of certain California state-adopted mathematics textbooks, grades one through three, was made by Reed to determine (1) the actual technical and supporting vocabularies introduced at each grade level, (2) the extent of agreement between these and the vocabularies introduced in the state-adopted basic readers at the same grade levels, and (3) the extent of agreement between mathematics vocabularies and those contained in certain standard word lists.

Two series of master lists were constructed--one series consisting of all technical words introduced at each grade level, and the other series consisting of all supporting words at each grade level. Each list was checked individually against (1) the cumulative vocabulary lists found in the two state-adopted basic reader series, and (2) against the words contained in the three recognized word lists: (a) Dale's "List of 3000 Familiar Words," (b) Dolch's "First Thousand

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[1] Ruth Margaret Frances Gallant, "An Investigation of the Use of Cloze Tests as a Measure of Readability of Materials for the Primary Grades," (unpublished Doctoral dissertation, Indiana University, 1964), quoted from *Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform*, XXV, May, 1965, Abstract No. 65-2370, (Ann Arbor: University Microfilms, 1965), pp. 6431-6432.

Words for Children's Reading," and (c) Dolch's "Basic Sight Vocabulary."

It was found that (1) little agreement existed between vocabularies introduced in the state-adopted mathematics textbooks and those introduced in the state-adopted basic reading series. Only nine of the 217 technical terms introduced in grades one through three were also introduced in both basic reader series. While 47 per cent of the grade-one supporting mathematics vocabulary was also introduced in both basic readers in the first-grade, this proportion decreased to 7 per cent in the third grade. (2) Greater agreement existed between mathematics text vocabularies and the three standard word lists. At least 50 per cent of the words introduced in both technical and supporting vocabularies also appeared on these standard word lists.[1]

The discussion of readability studies of books prepared for science classes has purposely been omitted from this section. The science textbook aspect of readability studies will be covered in the section which follows.

Readability studies started near the beginning of the twentieth century with studies of vocabulary and the preparation of word lists. This was followed by studies of how frequently words used in one book were repeated in other books of the series or grade level under study. Attempts to measure reading difficulty followed and led to the development of formulas for the determination of the reading difficulty of material prepared for children of the upper elementary grades.

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[1] Mary Katherine Stevens Reed, "Vocabulary Load of Certain State-Adopted Mathematics Textbooks, Grades One Through Three," (unpublished Doctoral dissertation, University of Southern California, 1965) quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXVI, January, 1966, Abstract No. 65-12, 264, (Ann Arbor: University Microfilms, 1966), p. 3706.

The study of whole words was followed by studies involving prefixes, suffixes, and syllables. Subject matter, qualitative elements of words, the style and format of the written material were also considered; however, these studies did not prove to be very productive in the development of more accurate formulas for the determination of reading difficulty.

Workers interested in readability now turned their attention to the reading difficulty of materials published for children of the first three grades and to the material published for children and adults beyond the upper elementary grades.

During the sixty years that these studies have been taking place, only sentence length and vocabulary appear to be reliable measures of reading difficulty for the general reader. These studies also appear to have produced better articulation of the vocabularies of books within one series or one grade and to some reduction of the vocabulary load of textbooks; however, it appears that much more has to be done in both of these directions than has been accomplished. New methods for the measurement of reading difficulty are still being developed and tested, and the older measuring devices are still being tested and refined. But in spite of all of this work, vocabulary seems to remain the primary key to the measurement of reading difficulty.

Science Books

In 1922, Glen Rader, a biology teacher, reported the difficulties his students were having in comprehending the material which was being presented in their textbooks. Because the difficulty appeared to be caused by the vocabulary of the textbooks, Rader began to record the words which were causing the students difficulty. He found that often the words were strictly technical words which belonged to the science of biology, but more frequently they were uncommon English words. In a list of 1,600 words which he selected from a biology textbook, 617 technical words did not appear in Thorndike's list of 10,000 common words.[1]

In 1924 Luella Cole pointed out that teachers of foreign languages did not expect their students to acquire a vocabulary of more than 800 to 1,000 words in a single year's study of a new language. On the other hand, quite often a student in history or any of the sciences had as great, or greater, vocabulary to master in addition to a very considerable amount of subject matter. Cole tabulated the list of words for history and general science as 1,045 and 1,564 respectively. She concluded that such an extensive vocabulary load in a history or general science textbook should lead one to question the advisability of using that textbook.[1]

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[1] Glen Rader, "The Vocabulary Burden of Junior High School Textbooks in Biology," Educational Research Bulletin, (I, February, 1922), pp. 223, 231-232.

In 1925 Powers also studied the vocabulary burden of biology textbooks. He found it to be considerably larger than that of the textbooks of chemistry or general science. His two main conclusions were as follows: (1) the extremely small number of words of high frequency and the large proportion with a single occurrence supported the charge that general science was superficial in its treatment of topics. (2) The vocabulary burden of all these textbooks was unnecessarily high.[2]

In 1938 Curtis published the results of one hundred investigations of the problems of vocabulary and its relationship to the teaching of science. Four of his conclusions were as follows: (1) pupils encounter in science textbooks many technical and nontechnical words the meanings of which they do not know. (2) There is insufficient provision in science textbooks for repetition of difficult scientific terms. (3) Too large a percentage of the difficult words in such textbooks are nonscientific or nontechnical. (4) Too small a percentage of the scientific terms that are introduced into such textbooks of science are defined. He further stated that, "In essence, it can be assumed defensibly that the vocabularies of textbooks in secondary science are too difficult for the pupils for whom the books are written."[1]

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[1] Luella Cole, "The Determination of the Technical Vocabularies of the School Subjects," School and Society, (XX, July 19, 1924), pp. 91-96.

[2] S. R. Powers, "A Vocabulary of High School Science Textbooks," Teachers College Record, (XXVI, January, 1925), pp. 368-392.

In a study reported in 1949 Kerr stated, "There is still a feeling on the part of many teachers that the only subject which needs carefully graded material is reading."[2] Because of this feeling, only the reading textbooks used by elementary school children are graded with great care in order to provide for growth in this skill. Careful grading of the books for the other subject areas appears to be ignored. As a result increased difficulties are placed in the paths of the students. As Kerr further stated, "since science and social studies both present many concepts which are remote in space or time, it is important that reading difficulties do not further complicate the problems."[1]

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[1] Francis D. Curtis, Investigations of Vocabulary in Textbooks of Science for Secondary Schools (Boston: Ginn and Company, 1938), pp. 115-116.

[2] Margaret Kerr, "Use of Readability Formulas in Selecting Textbooks," Elementary School Journal, (XLIX, March, 1949), p. 412.

In 1950 three studies of the readability of textbooks were reported by Mallinson and his associates. The first was concerned with the reading difficulty of the textbooks used in elementary science.[2] The second with the difficulty of high school biology textbooks,[3] and the third with the reading difficulty of junior high school science textbooks.[4]

In order to determine the reading difficulty of textbooks in elementary science, five series of elementary science textbooks were used. The books for the fourth-, fifth-, and sixth-grades were analyzed by means of the Flesch formula.[1] This formula uses the number of words in the sentences, the relative number of personal references, and the number of affixes and suffixes to the words. These things are measured, using a one-hundred-word sample of the material, and are translated into a reading-difficulty score by means of a formula. This score is then converted into a grade-level value of reading difficulty.[2]

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[1] Ibid.

[2] George G. Mallinson, Harold E. Sturm, and Robert E. Patton, "The Reading Difficulty of Textbooks in Elementary Science," The Elementary School Journal, (L, April, 1950), pp. 460-463.

[3] George G. Mallinson, Harold E. Sturm, and Lois M. Mallinson, "The Reading Difficulty of Textbooks for High-School Biology," The American Biology Teacher, (XII, November, 1950), pp. 151-156.

[4] George G. Mallinson, Harold E. Sturm, and Lois M. Mallinson, "The Reading Difficulty of Textbooks in Junior High School Science," The School Review, (LVIII, December, 1950), pp. 536-540.

Five one-hundred-word samples were taken from each book. To do this, each book was divided into five equal parts. A page was picked at random[3] from each of these parts by using a table of random numbers. If the page selected contained no reading material, another random selection was made. A one-hundred-word sample was taken from each page that had been selected by counting from the first word of the first new paragraph on that page. From these data an average reading difficulty for each book was calculated.[4]

Mallinson and his associates found that, in general, many of the textbooks in elementary science for fourth-grade were far too difficult for the fourth-grader of average reading ability. The fifth-grade textbooks in science were rather difficult for the average fifth-grader. The sixth-grade books were slightly difficult for the average sixth-grader. None could be construed as being easy reading material.[1]

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[1] Rudolf Flesch, The Art of Plain Talk (New York: Harper and Brothers, 1946).

[2] Mallinson, Sturm, and Patton, p. 461.

[3] Quinn McNemar, Psychological Statistics (New York: John Wiley and Sons, 1949).

[4] Mallinson, Sturm, and Patton, pp. 461-462.

In their study of the reading difficulty of textbooks used in junior high school science classes, Mallinson and his associates used ten textbook series which had been written as three-book series for grades seven, eight, and nine. They also used books for seventh- and eighth-grade from two series which were designed for grades one through eight.[2]

To determine the readability of these thirty-four textbooks, Mallinson and his associates used the same technique they developed for their previous studies. This technique was based upon the Flesch formula for determining readability.[3]

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[1] Ibid., p. 463.

[2] Mallinson, Sturm, and Mallinson, "The Reading Difficulty of Textbooks in Junior High School Science," p. 537.

[3] Ibid.

The conclusions reached by the authors were as follows: (1) All the textbooks for Grade VII, with the exception of three, have a grade level of difficulty equivalent to Grade VI completed. One of the three has a grade level of difficulty of Grade V completed and the other two of Grade VII completed. The average pupil would find that the textbooks were of reasonable difficulty. The students in the lower half of the class with respect to reading ability would find the textbooks rather difficult. Two of the textbooks would be fairly difficult for all but the better students.

(2) The textbooks for Grade VIII are not likely to be difficult for eighth-grade students to read, except for those students in the lower level of reading ability. The data further reveal that the average level of difficulty of all the textbooks for Grade VIII is below that for Grade VII.

(3) Textbooks for Grade IX have a greater range of difficulty than do those designed for Grades VII and VIII. Four of those designed for Grade IX would be of moderate difficulty for all but the students in the higher levels of reading ability. The other textbooks are not likely to be difficult, except for students in the lower levels of reading ability.

(4) Apparently, then, the textbooks for Grade VII are likely to be more difficult for the students for whom they are designed than are the textbooks for Grades VIII and IX

for the students for whom they are designed. If, however, the popular opinion that students in the junior high school are poor readers is true, it does not seem likely that any of the textbooks which were analyzed can be considered easy reading.

(5) It may be noted that the scores for the separate samples from each book, not shown here, gave no indication that the reading difficulty of the earlier samples of the textbooks was consistently lower than that of the later samples. Apparently, no provision is made for growth of reading ability through any grade.[1]

In 1951 Mallinson studied the readability of the high school science textbooks using the same technique, based upon the Flesch formula, that he and his associates had used before. Again it was found that many books have reading passages written at levels of difficulty which were too advanced for the students for whom they were intended.[2]

In 1952 Mallinson and his associates presented the results of four readability studies. In one study they examined the reading difficulty of the textbooks for general science;[1] in the second, the reading difficulty of high school physics textbooks;[2] in the third, both vocabulary and reading difficulty found in the teaching of junior high school science;[3] and in the fourth, the reading difficulty of high school chemistry textbooks.[4]

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[1] Ibid., p. 539.

[2] George G. Mallinson, "The Readability of High School Science Texts," The Science Teacher, (XVIII, November, 1951), pp. 253-256.

In the study made of sixteen physics books, Mallinson and his associates found that one textbook had a seventh-grade reading level, one a seventh-grade completed reading level, two an eighth-grade reading level, one an eighth-grade completed reading level, four a ninth-grade reading level, two a ninth-grade completed reading level, two a tenth-grade reading level, one a tenth-grade completed reading level, one high school completed reading level, and one college completed reading level.[5]

The investigators also found a great range in the reading difficulty of the individual textbooks. In one of the books with a ninth-grade completed reading level, it was found that the easiest passage had a reading level of the fifth-grade completed while the most difficult passage had a reading level of the college level.[1]

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[1] George G. Mallinson, Harold E. Sturm, and Lois M. Mallinson, "The Reading Difficulty of Textbooks for General Science," School Review, (LII, February, 1952), pp. 94-98.

[2] George G. Mallinson, Harold E. Sturm, and Lois M. Mallinson, "The Reading Difficulty of Textbooks for High-School Physics," Science Education, (XXXVI, February, 1952), pp. 19-23.

[3] George G. Mallinson, "Some Problems of Vocabulary and Reading Difficulty in Teaching Junior High School Science," School Science and Mathematics, (LII, April, 1952), pp. 269-274.

[4] George G. Mallinson, Harodl E. Sturm, and Lois M. Mallinson, "The Reading Difficulty of Textbooks for High-School Chemistry," Journal of Chemical Education, (XXIX, December, 1952), pp. 629-631.

[5] Mallinson, Sturm, and Mallinson, "The Reading Difficulty of Textbooks for High-School Physics," p. 22.

The eleven textbooks with a reading level of ninth-grade completed or below are not likely to be difficult for the average eleventh- or twelfth-grader taking physics, the usual grade placement for this course. They are also unlikely to cause great difficulty for the below average student. This conclusion, however, does not apply to individual passages which are difficult. On the other hand, there are two textbooks which are likely to be difficult for superior students, and one of these might be above the level of comprehension for even some college students.[2]

In a summary of some of the problems of vocabulary and reading difficulty in the teaching of junior high school science, Mallinson pointed out three important things that could reduce vocabulary and reading difficulties for the junior high school science student. These things were as follows: (1) It should be remembered that half of all students in any course are below average. Hence, the textbook selected should have a level of reading difficulty from one to one and one-half years below the level at which it is to be used. (2) Once a book has been selected it should be examined carefully to determine whether or not the difficult terms have been defined and explained either in the text or in the footnotes when they are used for the first time. (3) If the teacher finds a number of words that are likely to cause difficulty for the students, it may be wise to list them. The students should then be given specific instructions in their pronunciations, spellings, and meanings before the words actually appear in the text. Thus, it will not be necessary for the teacher to spend time correcting misconceptions that arise from the pupils' misunderstandings of such words.[1]

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[1] Ibid.

[2] Ibid., pp. 22-23.

In determining the reading difficulty of textbooks for high-school chemistry, Mallinson and his associates used twenty-two textbooks. They found that two were written at an eighth-grade reading level, four at an eighth-grade completed reading level, two at a ninth-grade reading level, eight at a ninth-grade completed reading level, three at a tenth-grade reading level, two at a tenth-grade completed reading level, and one at a high school completed reading level.[1]

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[1] Mallinson, "Some Problems of Vocabulary and Reading Difficulty in Teaching Junior High School Science," p. 273.

While chemistry is usually offered in either the eleventh- or twelfth-grades, there is a very considerable range in the reading level of the textbooks for the course. In one textbook the easiest passage had a seventh-grade reading level while the most difficult passage had a college completed reading level.[2]

The easiest textbook has an average reading level of seventh-grade. It is unlikely that this textbook will prove difficult for many students likely to be enrolled in chemistry, especially if it is offered in either the eleventh- or twelfth-grades. In contrast, the most difficult textbook with an average level of reading difficulty of high school completed is likely to be difficult for all but the very superior students. In fact, the next five textbooks below the most difficult one are all likely to be difficult for many of the students likely to be enrolled in the high school chemistry course.[3]

In 1954 the reading grade levels of elementary science textbooks, as predicted by the Yoakam technique, were compared with the grade levels designated for them by the publishers. It was found that only eighteen of the forty-one textbooks examined were designated properly. This study by Burkey showed seven of the books to be below the grade levels to which they had been assigned and sixteen were found to be above the grades to which they had been assigned. In other words, more than one-half of the science textbooks had been placed either too high or too low by the publishers.

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[1] Mallinson, Sturm, and Mallinson, "The Reading Difficulty of Textbooks for High-School Chemistry," p. 631.

[2] Ibid., p. 630.

[3] Ibid., pp. 630-631.

When a textbook rated higher than the grade level to which the publisher had assigned it, it was examined to determine the percentage of the vocabulary load resulting from the use of technical words. It was found that 35 per cent of all the difficult words were of the technical variety. Technical vocabulary, therefore, was not the only contributing factor in the difficulty. The study indicated that there were extreme internal variations in the readability levels of the reading matter within the textbooks.[1]

In 1954 the Mallinson group turned its attention to the reading difficulty of general physical science and earth science textbooks. As in all previous studies the technique of analysis was practically the same and based upon the Flesch readability formula.

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[1] Jacob Eugene Burkey, "The Readability Levels of Recently Published Elementary Science Textbooks," (unpublished Doctoral dissertation, University of Pittsburgh, 1954), pp. 1-81., quoted from Sloan, pp. 72-73.

The analysis of the eleven physical science texts produced a considerable range in readability levels. One book was written at an average reading level of the seventh-grade, two at a seventh-grade completed reading level, three at an eighth-grade reading level, one at an eighth-grade completed reading level, two at a ninth-grade reading level, one at a tenth-grade reading level, and one at a tenth-grade completed reading level.[1]

The analysis of the seven earth science textbooks produced a considerable range in readability levels. Three of the books were written at an average reading level of the eighth-grade, one at an eighth-grade completed reading level, one at a ninth-grade reading level, and two at a tenth-grade reading level.[2]

In one of the physical science textbooks the easiest passage had a reading level of the seventh-grade and the most difficult had a reading level of the college grade. In one of the earth science textbooks the easiest passage had a reading level of the eighth-grade and the most difficult had a reading level of college completed.[3]

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[1] George G. Mallinson, Harold E. Sturm, and Lois M. Mallinson, "The Reading Difficulty of Textbooks for General Physical Science and Earth Science," School Science and Mathematics, (LIV, November, 1954), p. 614.

[2] Ibid., p. 615.

[3] Ibid.

If the earth science course is an eighth grade course, the three easiest textbooks will be very difficult for over half of the class, and difficult for the rest. If physical science is a ninth-grade course, over half of the textbooks should not be too difficult for most of the students.[1]

In 1955 Major found that biology textbooks were too difficult for most college freshmen who were participants in his study. However, it was found that when adjustments were made in certain reading passages to reduce the level of reading difficulty, reading comprehension increased significantly for the above-average and average students.[2]

Also in 1955, Mallinson and his associates studied the reading difficulty of unit-type textbooks for elementary science. Unit-type textbooks are usually of pamphlet size and consist of subject matter dealing with individual areas of science, such as television, rocks, and heat, instead of covering the breadth of areas usually found in textbooks.[3]

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[1] Ibid., pp. 615-616.

[2] Alexander G. Major, "Readability of College General Textbooks and the Probable Effect of Readability Elements on Comprehension," (unpublished Doctoral dissertation, Syracuse University, 1955), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XV, March, 1955, Abstract No. 12,703 (Ann Arbor: University Microfilms, 1955), pp. 1573-1574.

[3] George G. Mallinson, Harold E. Sturm, and Lois M. Mallinson, "The Reading Difficulty of Unit-Type Textbooks for Elementary Science," Science Education, (XXXIX, December, 1955), p. 407.

Books for grades four, five, and six were furnished by five publishers. It was found that most of this material was likely to be too difficult for the average fourth- and fifth-grader. It was most suitable for sixth-grade students of average or better reading ability.[1]

Mallinson's group summarized their results as follows:

> It may be stated that if teachers have found textbooks of elementary science generally too difficult, they are not likely to find the unit-type textbooks much better if they use them at the grade levels that the publishers suggest. However, it is recognized that these textbooks may be used suitably, in so far as reading difficulty is concerned, at higher grade levels. Further, it is probably easier to shift these pamphlet-type materials to suit reading abilities than to shift textbooks. However, there is less likely to be integration among the areas dealt within the unit-type textbooks, than among the areas found in conventional textbooks.[2]

In 1957 the Mallinson group reported that recent science textbooks had not improved in readability. They said that if the appropriate level of reading difficulty of a textbook was considered to be one grade level below that of the student for whom it was intended, only a few could be considered suitable.[3]

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[1] *Ibid.*, pp. 408-410.

[2] *Ibid.*, p. 410.

[3] George G. Mallinson, Harold E. Sturm, and Lois M. Mallinson, "The Reading Difficulty of Some Recent Textbooks for Science," *School Science and Mathematics*, (LVII, May, 1957), pp. 364-366.

Crook and Smith, also in 1957, utilized the Flesch readability formula and found that even at the college level many textbooks in the field of science were not at an easy reading level for college students.[1]

In 1961 Belden and Lee analyzed the five biology textbooks selected by a state textbook committee. These books were analyzed by using the Dale-Chall formula. Three hundred and fifty-seven students enrolled in tenth-grade biology were given the Nelson-Denny Reading Test, Form A Revised Edition.[2]

The books to be examined were lettered A, B, C, D, and E. It was found that Book A could be read by only 37 per cent of the students. Book B was usable to 39.5 per cent of the students; Book C was useful to 42.3 per cent of the students; Book D to 49.6 per cent; and Book E to 58.5 per cent of the students. Thus, out of the five books examined, the readability scores of over half of the students were below the readability score of the textbook.[3]

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[1] Kenneth Crook and Charles Smith, "The Reading Problem in College Science Instruction," Science Education, (XLI, February, 1957), pp. 54-55.

[2] M. J. Nelson and E. C. Denny, The Nelson-Denny Reading Test, Form A., Revised Edition, (Boston: Houghton Mifflin Company, 1960).

[3] Bernard R. Belden and Wayne D. Lee, "Readability of Biology Textbooks and the Reading Ability of Biology Students," School Science and Mathematics, (LXI, December, 1961), pp. 689-693.

That same year Jacobson used still another technique to examine the reading difficulty of physics and chemistry textbooks in use in Minnesota. Reading difficulty was determined by the Underlining Test. Thus the relative difficulty of a passage from a chemistry or physics book was defined as the number of words underlined by chemistry and physics students.

Rank-difference correlation coefficients were calculated for a student's rank on a vocabulary test and on the number of words underlined. Because students with larger vocabularies underline fewer words, the Underlining Test was considered valid.

Based upon this study it was recommended that: (1) reading difficulty be an important criterion for selecting physics and chemistry textbooks; (2) the equations developed be used to determine the reading difficulty of physics and chemistry material; and (3) future reading difficulty studies be conducted separately for physics and chemistry and further consideration be given to the variables appearing in the four regression equations.[1]

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[1] Milton Durwood Jacobson, "Reading Difficulty of Physics and Chemistry Textbooks in use in Minnesota," (unpublished Doctoral dissertation, Unversity of Minnesota, 1961), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available In Microform, XXII, May, 1962, Abstract No. 62-1790, (Ann Arbor: University Microfilms, 1962), pp. 3950-3951.

In 1962 Belden and Lee examined five chemistry and five physics textbooks selected by state textbook committees. As they had done in their previous study, the textbooks were analyzed by means of the Dale-Chall formula. One hundred and thirty-five students enrolled in nine sections of eleventh-grade chemistry and sixty-two students enrolled in four sections of twelfth-grade physics were given the Nelson-Denny Reading Test, Form A, Revised Edition.[1]

These investigators found that of the five chemistry textbooks examined, none would be of use to half or more of the class. The most difficult would be readable to 34 per cent of the eleventh-grade students, and the easiest to 47 per cent of these students.

The physics books presented a different picture. All would be usable to 50 per cent or more of the class. The most difficult would be readable to 62 per cent of the twelfth-grade students, and the easiest to 90 per cent of these students.[2]

Williams studied the effect of rewritten science textbook materials on the reading ability of sixth-grade pupils. In order to do this the readability level of three well known sixth-grade science textbooks was determined by using the Yoakam Readability Formula. One chapter from one of the textbooks was selected for use in the investigation.

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[1] Nelson and Denny

[2] Bernard R. Belden and Wayne D. Lee, "Textbook Readability and Reading Ability of Science Students," The Science Teacher, (XXIX, April, 1962), pp. 20-23.

Four hundred and seventeen pupils were randomly selected to form the control and experimental groups. Within the two groups, the students were stratified according to their reading achievement determined from the Stanford Achievement Test. Three achievement levels were used: (1) those pupils reading above grade level, (2) those at grade level, and (3) those below grade level.

The following conclusions were reached: (1) rewriting sixth-grade science textbook selections, through simplification of style and vocabulary and amplification of technical vocabulary helped sixth-grade pupils to significantly increase their reading rate and reading comprehension; (2) sixth-grade pupils with low reading ability read with greater speed and understanding when they were provided science reading materials which were more closely written to their reading achievement level; (3) sixth-grade pupils with average and above average reading ability read with greater speed and comprehension when they read science textbook materials which were rewritten to a lower level of readability than when they read sixth-grade level science textbook materials; (4) sixth-grade pupils with average and above average reading ability comprehend better than poor readers even when the good readers read science textbook materials especially prepared for poor readers.[1]

In 1965 Ottley studied twelve science textbooks which had been published between 1959 and 1962. Four textbooks had been published for the fourth-grade, four for the fifth-grade, and four for the sixth-grade. These twelve books were analyzed by means of the Lorge formula for readability. Ottley reported that "The directions of the formula were followed in finding the sentence length, number of prepositional phrases, and number of hard words from every tenth page. Grade levels for the individual pages were computed; these were then averaged to find the grade level of the book."[2]

It was found that fourth-grade books averaged at a grade level of 4.6; fifth-grade books at 5.1; and sixth-grade books at 5.2. Difficulty ranged from 3.55 in a fourth-grade book to 6.98 in a fifth-grade book.[3]

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[1] David Lee Williams, "The Effect of Rewritten Science Textbook Materials on the Reading Ability of Sixth-Grade Pupils," (unpublished Doctoral dissertation, University of Illinois, 1964), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available In Microform, XXV, May, 1965, Abstract No. 65-3695, (Ann Arbor: University Microfilms, 1965), p. 6442.

[2] LeRoy Ottley, "Readability of Science Textbooks for Grades Four, Five, and Six," School Science and Mathematics, (LXV, April, 1965), p. 364.

[3] Ibid., pp. 364-365.

In a study reported in 1966, Morgan and Koelsche compared the objectives, principles, and vocabularies of chemistry on the secondary school level over a thirty-year period. Selected high school chemistry textbooks published from 1934 to 1965 were composed of three series of traditional textbooks from major publishers and the texts of the Chemical Education Material Study and the Chemical Bond Approach Project. In addition, a vocabulary list was compiled from 2,999 science articles appearing in newspapers and magazines.[1]

The findings reported here related only to the vocabulary studies. It was found that word content varied considerably. "With the exception of a few terms generally used in a more detailed study of atomic and molecular structure found only in the new curriculum texts, other words and terms were more likely to be found in the traditional texts. If it is assumed that knowledge of these words and terms contributes to the scientific literacy of the general public, this knowledge is more likely to come from the traditional text."[2]

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[1] Ashley G. Morgan, Jr. and Charles L. Koelsche, "An Investigation and Comparison of the Vocabularies, Principles, and Objectives of Textbooks in High School Chemistry and Popular Literature," School Science and Mathematics, (LXVI, January, 1966), pp. 36-50.

[2] Ibid.

Mallinson pointed out, in several of his works, the following five things: (1) The reading levels of many textbooks are too advanced for the students for whom they are written. (2) The failure of many students to achieve in subject-matter areas may be caused partly by the levels of reading difficulty of the textbooks in these areas. (3) The levels of reading difficulty of textbooks within any subject-matter area differ greatly. (4) Teachers should select textbooks using the level of reading difficulty as a criterion. (5) Publishers need to take greater cognizance of the levels of reading difficulty of the textbooks they produce.[1]

There are many people who do not agree with Mallinson concerning these things. They believe that the human mind is like a muscle and that it must be constantly exercised and stretched to do its best work.[2] It is the belief of the author that there is a certain optimum weight which will provide the individual with the proper amount of exercise if it is used. If this weight is exceeded by too much additional weight, the individual may be injured if he tries to lift it. The same thing seems to be true of written material. It is entirely possible that the subject matter may possess sufficient difficulty of comprehension to exercise and stretch the mind of the student. If an additional load is added by difficult vocabulary, the load may become too great for the student, and his ability to comprehend the subject may be impaired. Then it becomes a problem of whether the mastery of the subject matter or the language in which it is written is the goal which the teacher is trying to reach. It would appear from the many studies cited that difficult subject matter written in difficult language presents a greater burden than the average student can be expected to accomplish. If this is true, then one burden or the other should be reduced. Since reducing the difficulty of certain subject matter areas does not appear to be possible, the alternative seems to be a reduction in vocabulary burden.

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[1] Mallinson, Sturm, and Mallinson, "The Reading Difficulty of Textbooks in Junior High School Science," p. 536.

[2] Van Cleve Morris, Philosophy and the American School (Boston: Houghton Mifflin Company, 1961).

Illustration of Readability Formulas

In order to illustrate one of the techniques of measuring readability, a brief discussion of the procedures for using three of the formulas is presented.

The Yoakam formula was developed by Gerald A. Yoakam of the University of Pittsburgh. The following steps are used in applying the Yoakam formula: (1) the pages to be sampled are selected by dividing the total number of pages by fifteen, the size of the sample to be used. The resulting quotient is the interval between sample pages. This gives an evenly distributed sampling of the book. (2) The average number of words on a page is determined. (3) All words with a Thorndike rating of four or more are noted on a data sheet. The Thorndike index numbers of these words are added for each sample page. This sum is the page index number. (4) The fifteen-page index numbers are added and this total is divided by fifteen, the size of the sample. The resulting quotient is the book index number. (5) The grade placement of the book is then determined by reference to a table prepared specifically for this purpose.[1]

The Flesch formula was developed by Rudolf Flesch at Teachers College, Columbia University. The following steps are used in applying the Flesch formula: (1) twenty-five to thirty sample pages of a book are picked at random by a purely numerical scheme. (2) Samples of one hundred words each are selected, starting each sample at the beginning of a paragraph. (3) The average number of words in the sentences is calculated. If the one hundredth-word is less than half way through the sentence, that sentence is not counted. If the one hundredth-word is more than half way through the sentence, the fragment is counted as a sentence. Also, each unit of thought which is grammatically independent of another sentence or clause, if its end is marked by a period, question mark, exclamation point, semicolon, or colon, is counted as a sentence. Incomplete sentences or sentence fragments are also counted as sentences. (4) The total number of words from all samples is divided by the total number of sentences from all samples. The quotient is rounded off. (5) The average word length in syllables is calculated. If one hundred-word samples are used, the total number of syllables in all samples is counted and the sum is divided by the total number of samples. (6) To find the "Reading Ease Score" multiply the average sentence length by 1.015, multiply the number of syllables per one hundred-words by 0.846, add these two products and subtract the sum from 206.835. The remainder is the "Reading Ease Score." The grade placement of the material is determined from Table 2.[1]

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[1] Gerald A. Yoakam, Basal Reading Instruction (New York: McGraw-Hill Book Company, Inc., 1935).

The Dale-Chall formula was developed by Edgar Dale and Jeanne S. Chall at Ohio State University. The following steps are used in applying the Dale-Chall formula: (1) a sample of approximately one hundred words is selected from about every tenth page of the book. The sample is never begun or ended in the middle of a sentence. (2) The total

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[1] Rudolf Flesch, How to Test Readability (New York: Harper and Brothers, 1951), pp. 1-4.

TABLE 2

MEANING OF READING EASE SCORE[1]

Reading Ease Score	Description of Style	Typical Magazine	Syllables per 100 Words	Average Sentence Length	Grade Placement[a]	Average Grade Completed[b]	Per cent of U. S. Adults[c]
90 - 100	Very Easy	Comics	123	8	5	4	93
80 - 90	Easy	Pulp Fiction	131	11	6	5	91
70 - 80	Fairly Easy	Slick Fiction	139	14	7	6	88
60 - 70	Standard	Digests, *Time*, Mass Non-fiction	147	17	8 - 9	7 or 8	83
50 - 60	Fairly Difficult	*Harper's* *Atlantic*	155	21	10 - 12 (high school)	some high school	54
30 - 50	Difficult	Academic Scholarly	167	25	13 - 16 (college)	high school or some college	33
0 - 30	Very Difficult	Scientific Professional	192	29	College Graduate	College	4 1/2

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[1] *Ibid.*, pp. 6, 43-44.

[a] Grade placement of the content of the book analyzed.

[b] From 1950 census figures about the education of our adult population showing school grades completed, i.e. 5th grades means 4th grade completed.

[c] Per cent of the U. S. adults who have completed the grade indicated in the previous column.

number of words is counted and this is recorded under No. 1 on the work sheet which is illustrated as Figure 2. (3) The number of sentence is counted and recorded under No. 2 on the work sheet. (4) The number of unfamiliar words is counted and recorded under No. 3 on the work sheet. Words which do not appear on the Dale list are considered unfamiliar. (5) The average sentence length is computed by dividing the number of words in the sample by the number of sentences in the sample. The quotient is recorded under No. 4 on the work sheet. (6) The Dale score, or the percentage of words outside the Dale list, is computed by dividing the number of words not on the Dale list by the number of words in the sample and by multiplying by one hundred and recorded under No. 5 on the work sheet. (7) The average sentence length is multiplied by 0.0496 and recorded under No. 6 on the work sheet. (8) The Dale Score is multiplied by 0.1579 and recorded under No. 7 on the work sheet. (9) The two products so obtained are added to a constant 3,6365 to obtain the raw score. The raw score is rounded off to one decimal place and recorded under No. 9 on the work sheet. From Table 3, the raw score is converted into the grade placement of the material.[1]

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[1] Edgar Dale and Jeanne S. Chall, "Formula for Predicting Readability," Educational Research Bulletin, (XXVII, January 21, and February 17, 1948), pp. 37-41.

FIGURE 2

SAMPLE WORK SHEET FOR THE DALE-CHALL FORMULA[1]

Article:________________________	Page No.____	Page No.____	Page No.____
Author:________________________	From________	From________	From________
Publisher:____________ Date:________	To________	To________	To________
1. Number of words in the sample................	________	________	________
2. Number of sentences in the sample............	________	________	________
3. Number of words not on Dale list.............	________	________	________
4. Average sentence length (divide 1 by 2)......	________	________	________
5. Dale score (divide 3 by 1, multiply by 100)..	________	________	________
6. Multiply average sentence length(4) by .0496.	________	________	________
7. Multiply Dale score (5) by .1579.............	________	________	________
8. Constant.....................................	________	________	________
9. Formual raw score (add 6,7, and 8)...........	________	________	________

Average raw score of ____ samples.....________ Analyzed by:__________ Date:________

Average corrected grade-level..........________ Checked by: __________Date:________

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[1] *Ibid.*, p. 43.

Selection of a Formula

One of the first problems which must be solved in making readability determinations is the selection of the most appropriate formula from the many which now exist. Most of the formulas have been tested many times since they were first published.

In 1951 the Dale-Chall, Flesch, Lorge, Lewerenz, Washburne-Morphett, and Yoakam formulas were compared by Russell and Rea. They wanted to determine which would give a grade placement most nearly in agreement with ratings of juvenile fiction made by sixty-three children's librarians. These librarians represented libraries in ten states. It was concluded that within the limits of the sample of books

TABLE 3

CORRECTION TABLE[1]

Formula Raw Score	Corrected Grade-Levels
4.9 and below.	4th grade and below
5.0 to 5.9	5-6th grade
6.0 to 6.9	7-8th grade
7.0 to 7.9	9-10th grade
8.0 to 8.9	11-12th grade
9.0 to 9.9	13-15th grade
10.0 and above	16+(college graduate)

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[1] *Ibid.*, p. 42.

used and the criterion measure of the judgments of the librarians, that the Dale-Chall, Flesch, and Lorge formulas appeared to be better instruments for measuring the difficulty of juvenile fiction books than were the Lewerenz, Washburne-Morphett, and Yoakam Formulas.[1]

The purpose of another 1951 study, which was made by Michaelis and Tyler, was to apply three formulas frequently used in measuring readability to discover whether materials rated as readable at a certain grade level were understandable to students at that grade level. The three formulas used were the Lorge, Flesch, and Dale-Chall. The reading ability of the pupils in the study was determined by means of the Iowa Silent Reading Test (Form Cm).

The authors concluded that the Dale-Chall and Flesch formulas gave the closest relationship between reading ability and the readability of the materials analyzed.[2]

In 1958 Finkelstein wrote a textbook dealing with contemporary world problems. This book was prepared in accordance with the principles outlined in both the Flesch and Dale-Chall formulas.[1]

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[1] David H. Russell and Henry R. Rea, "Validity of Six Readability Formulas as Measures of Juvenile Fiction," Elementary School Journal, (LII, November, 1951), pp. 136-144.

[2] J. U. Michaelis and F. T. Tyler, "Comparison of Reading Ability and Readability," Journal of Educational Psychology, (XLII, December, 1950), pp. 491-498.

In 1960 Inskeep made a study which had for its purpose: (1) the comparison of three methods of readability estimation; and (2) the evaluation of a prepared readability scale. The scale consisted of six graded passages plus instructions for estimating readability. The methods of estimation were: (1) formula computation; (2) teacher estimation, with scale; and (3) teachers estimation, without scale.

Ten reading selections were chosen from current children's non-fiction reading books. These selections were: (1) rated by readability formula (Spache for primary levels, Dale-Chall for others); (2) given to two groups of forty teachers each, one group estimating the readability with the scale, one estimating without the scale; and (3) read by 497 children, grades three through five, along with a test of four multiple choice comprehension questions for each selection. The children were also given the Gates Reading Survey, comprehension test.

Inskeep concluded: (1) The readability scale seems to help teachers to estimate readability, within the range of the scale; (2) the scale appeared to have no effect in reducing the variability of teacher estimates; (3) teacher estimates tend to be closer to the formula than to children's levels; (4) no one of the methods of estimation agrees closely with the children's comprehension; (5) all methods of estimation and children's levels agree closely as to relative ranked difficulty.[1]

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[1] Milton Finkelstein, "A Text in Contemporary World Problems Written in Accordance with Selected Readability and Interest Formulas," (unpublished Doctoral dissertation, New York University, 1958), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XIX, May, 1959, Abstract No. 59-1055, (Ann Arbor: University Microfilms, Inc., 1959), pp. 2840-2841.

In 1961 Moore wrote three science units for use with low-ability junior high school students. These units were written at a fifth-sixth-grade reading level. Both the reading level of the units and of three general science books were determined by means of the Dale-Chall formula.

Based upon his tests with these materials the following conclusions seem justified: (1) the experimental text-type science units prepared by the investigator were more effective than standard science textbooks in enhancing the low-ability ninth-grade student's achievement on an objective test on science concepts; (2) the levels of reading difficulty of the experimental units were more appropriate than those of selected ninth-grade science textbooks for low-ability ninth-grade students; (3) by making adjustments in the vocabulary load, sentence structure, number and abstractness of concepts presented, method of organization and presentation, directness of approach, and the style of composition, the researcher was able to prepare science instructional materials having a degree of readability commensurate with the capabilities of the low-ability ninth-grade student; and (4) the factors previously cited made the experimental units easy to read and understand, but according to ratings by science teachers they were equal to or superior to corresponding sections from standard general science textbooks with respect to scope of science concepts, and accuracy and effectiveness in presenting science information.[1]

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[1] James Edward Inskeep, Jr., "A Comparison of Several Methods of Estimating Readability of Elementary School Reading Material," (unpublished Doctoral dissertation, University of Minnesota, 1960), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXI, October, 1960, Abstract No. 60-3520, (Ann Arbor: University Microfilms, Inc., 1960), p. 822.

In 1962 McTaggart attempted to determine the experimental validity of two readability formulas, the Flesch formula and the Dale-Chall formula. The students used in the experiment were studied by means of the Kilander Health Knowledge Test, the Henmon-Nelson Tests of Mental Ability, and diagnostic reading tests.

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[1] Arnold John Moore, "The Preparation and Evaluation of Unit Text Materials in Science for Low-Ability Junior High School Students," (unpublished Doctoral dissertation, State University of Iowa, 1961), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXII, November, 1961, Abstract No. 61-4040, (Ann Arbor: University Microfilms, Inc., 1961), p. 1471.

McTaggart concluded that (1) the Flesch and Dale-Chall readability formulas had essentially equal validity when used to determine various levels of reading difficulty for the respective health passage comprehension tests. In both tests, differences in student comprehension occurred that were significant over a two-grade range. (2) Students in the good health knowledge section made significantly better scores on both the Flesch and Dale-Chall health passage comprehension tests than students in the poor health knowledge section. (3) The Flesch Readability Formula was more effective, when judged by mean comprehension scores, than the Dale-Chall formula in assessing the reading difficulty of high school health textbook material for students who had good health knowledge scores. (4) The Dale-Chall Readability Formula was more effective, when judged by mean comprehension scores, than the Flesch formula in assessing the reading difficulty of high school health textbook material for students who had poor health knowledge scores. (5) In general, the greater the measured differences in readability scores for the health passages, the greater the probability of finding significant differences in student comprehension. (6) The procedures recommended by Flesch and by Dale and Chall for increasing the readability of reading materials apparently were effective. When the comprehension scores of all students in this study were compared, those reading the most difficult passages made the lowest scores and those reading the easiest passages made the highest scores, although these differences were not always significant. (7) Essential technical health vocabulary and basic health concepts and topics need not be sacrificed when making high school health textbook passages more readable. These aspects were not changed when the original (ninth-grade) versions were rewritten to the seventh- and twelfth-grade difficulty levels.[1]

In 1963 Lee also tested the Dale-Chall formula. His study was designed to investigate the validity of the Dale-Chall Readability Formula when this formula was used to predict the reading comprehension difficulty of twelve passages drawn from the general psychology textbook used at Oklahoma State University. Three hundred ninety-six students enrolled in ten randomly selected sections of General Psychology comprised the sampling population. These students were asked to respond to a Test of Comprehension constructed from twelve pasages of general psychology textbook material. The statistical method selected for determining the significance of difference between the original coefficient of the Dale-Chall formula and the coefficient obtained in this study was the t test. The Nelson-Denny Reading Test, 1960 Revision, was used to measure the reading level of students.

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[1] Aubrey Charles McTaggart, "An Experimental Validation of the Flesch and Dale-Chall Readability Formulas on High School Health Texts," (unpublished Doctoral dissertation, University of Illinois, 1962), quoted from _Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform_, XXIII, January, 1963, Abstract No. 62-6192, (Ann Arbor: University Microfilms, Inc., 1963), p. 2376.

The findings and conclusions indicated that the reading test separated the 396 students into 10 grade-equivalent groups. A coefficient of .7558 was obtained by correlating the readability index of each passage with the reading-grade level of the grade-equivalent groups in which 75 per cent of each group were able to answer three or four questions correctly on that passage. When the null hypothesis was tested, there was no significant difference between the original coefficient of the Dale-Chall formula and the coefficient obtained from data in this study. The researcher concluded that the Dale-Chall Readability Formula may be a valid predictor of comprehension difficulty of general psychology textbook material, but other studies are needed to support the findings of this present study before too many inferences can be made.[1]

Because there is evidence to support the workability of most of the published readability tests, the Dale-Chall formula was selected for this study for the following two reasons: (1) it was the formula used to determine the reading level of the Earth Science Curriculum Project material,[1] and (2) it is a relatively easy and rapid formula to use.

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[1] Wayne Dale Lee, "Readability of General Psychology Textbook Material: A Cross-Validation Study of the Dale-Chall Readability Formula," (unpublished Doctoral dissertation, Oklahoma State University, 1963), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXV, July, 1964, Abstract No. 64-8930, (Ann Arbor: University Microfilms, Inc., 1964), p. 939.

Textbook Selection

A study made by Lawrence in 1961 seems to be important enough to deserve to be quoted.

> This study was designed to determine how school administrators and teachers perform the responsibility of selecting high school textbooks for use in the districts of Los Angeles County, to evaluate the performance of this responsibility, and to recommend measures for improvement.
>
> District statements of criteria for high school textbook selection were requested on a state-wide basis. An interview instrument was then constructed which incorporated the major criteria common to most district statements. This instrument, which was validated through a pilot study, was designed to ascertain specific practices in the various aspects of evaluation. Structured interviews were then conducted with administrators and teachers in all districts maintaining high schools in Los Angeles County.
>
> Findings. (1) Over 73 per cent of the districts in California reported that they had no stated guidelines for high school textbook selection. (2) The role of the textbook in nearly all districts in the state was reported to be that of providing the major organization and content of the course of study. Statements of criteria received from 86 of the districts were constructed to support this role. (3) In applying major criteria, the methods used by some reviewers

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[1] John W. Shrum, ESCP Director of Teacher Preparation, personal communication.

in preliminary screening to eliminate obviously undesirable material was the only method for judging reported by other reviewers. (4) Lack of thorough examination was most frequently named by administrators and teachers as the major deterrent to wise textbook selection. (5) Most recommendations for improving textbook selection related to district efforts. Those recommendations of teachers and administrators which related to other agencies expressed the need for service rather than control.

Conclusions. (1) For most teachers and students in the high schools of California, the textbook is the major determining factor in the organization and content of the course of study. (2) This role of the textbook has not emerged from local use, experimentation, and research guided by the best resources available. (3) While a major degree of stereotyping of the place of the textbook in secondary education has been accomplished by state legislation and by the State Department of Education procedures, no significant purpose is served by the state list of textbooks. (4) Districts need more help and fewer regulations with respect to textbook selection. (5) High school textbook selection in many districts is casual, disorganized, and unrelated to the program of curriculum development and supervision. (6) High school personnel are not satisfied with the state framework within which they select textbooks nor with their own performance on this professional responsibility.

Recommendations. (1) A thorough reappraisal should be made of the role of the textbook in the secondary schools of California. (2) The ties should be strengthened between local district course of study adoption, and local district textbook selection. (3) The county and state superintendents' offices should give assistance, without domination, to those districts who do not consider their resources adequate to perform a professional review of all textbooks in all fields. (4) Local districts should provide assistance to teachers in textbook selection commensurate with its importance.

Specific proposals were made to implement each of these major recommendations. They include changes in state legislation and in procedures of the State Department of Education. They also relate to services which should be provided at the county and state levels and to modifications of practice at the local district level.[1]

SUMMARY

The history of readability analysis has been traced by Flesch,[2] Berelson,[3] and Sloan.[4] The one that follows is based upon the study made by Berelson.

Beginning with their interest in school books and children's literature and later stimulated by the growth of the adult education movement, educators have endeavored to determine the elements in communication content which make it easy or hard to read and comprehend. They were and are interested in the concrete factors that distinguish the easy from the hard book. They were and are interested in the stylistic differences. The answers to the questions which developed from this interest were used by educators in the selection and even the production of appropriate books for readers of limited ability.

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[1] John Dennis Lawrence, "The Application of Criteria to Textbooks in the Secondary Schools of Los Angeles County," (unpublished Doctoral dissertation, University of Southern California, 1961), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXII, March, 1962, Abstract No. 61-6295, (Ann Arbor: University Microfilms, Inc., 1962), pp. 3118-3119.

[2] Rudolf Flesch, Marks of a Readable Style (New York: Teachers College, Columbia University, 1943), pp. 3-8.

[3] Bernard Berelson, Content Analysis in Communcation Research (Glencoe, Illinois: The Free Press, 1952), pp. 63-64.

[4] Sloan, pp. 20-92.

In a sense, the development of readability measures is a story of increasing differentiation. In the beginning of such analysis was the word. The first studies of readability in the mid-1920's classified materials simply on the basis of the proportions of "easy" and "hard" words they contained, as indicated by a standard word list, usually the Thorndike list. In the following decade additional factors were investigated--sentence length, simple sentences, indeterminate clauses, prepositional phrases. Then followed a thorough investigation of no fewer than eighty-two assumed elements of difficulty, of which five were finally selected by Gray and Leary as correlating best with tests of comprehension: different words, different hard words, personal pronouns, and sentence length. This set of content characteristics was next reduced to three: hard words, prepositional phrases, and sentence length and they were included in a formula by Lorge which directly expressed readability in terms of years of schooling required for easy reading of the passage. At about the same time another widely used formula contained a different set of three factors: sentence length, personal references, and affixes was developed by Flesch. A third formula based on the number of words not on a certain list and on average sentence length was constructed by Dale and Chall to overcome criticisms of Flesch's formula. Flesch's formula was later divided into two facets of readability: "reading ease" and "human interest."[1]

One of the limitations to the applicability of readability analyses is that they have been validated against reading comprehension tests of general readers representing different educational groups. Hence, they apply to the general reader with general interest, and they do not take into account the effect upon readability of the reader's own special interests. For example, a salesman and an automobile mechanic could have approximately the same amount of schooling. Material regarding business trends which would be easy reading for the salesman could be quite difficult for the mechanic. In turn, technical information which would be easily understood by the mechanic could be extremely difficult reading for the salesman. Readability is a function of the reader's interest and experience, and this may seriously qualify its mechanical application. Furthermore, the formal categories in terms of which readability is normally measured do not take into account such factors as organization of the material, nature of the content, format, etc. For example, Flesch in developing his formula used True Confessions as an example of material which would be easy to read and the American Scholar as difficult to read. While it is quite likely that there are significant differences in vocabulary and sentence length in these two magazines, there is also a fundamental difference in content, the subjects being discussed, which would also exert a large influence upon the ease with which the material could be read. But as yet, we have no reliable nor valid way of measuring these differences in content. Thus, any readability formula must be applied with sound reason and judgment, and not just mechanically.[1]

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[1] Berelson, pp. 63-64.

Another factor must be considered in any discussion of readability analysis. Take science textbooks for an example. These books were first investigated in the 1920's, and intensively investigated by Mallinson and his associates in the 1950's. In spite of this work little improvement has been noted in the improvement of readability of these books. This is in part due to the places where the results of these investigations are reported. Dissertations and educational journals are not normally read by the general public. To make the situation more difficult for those who desire to make improvements in the readability of textbooks, most of the books studied cannot be easily identified. In most cases both the title and publisher are hidden in a code letter which is usually not decoded in the report. It is quite likely that these are two of many factors which have retarded the improvement of readability of textbooks.

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[1] *Ibid.*, p. 65.

REVIEW OF THE LITERATURE RELATED TO THE SURVEY OF TEXAS SCHOOLS AND TEACHERS

The literature which deals with the preparation of teachers to teach earth science, with the adequacy of the schools' equipment for this subject matter area, and with the relative merits of earth science as compared with general science, seems to fall into about four subdivisions. The four subdivisions are as follows: (1) the preparation, or science background, of school teachers. Usually included with this topic are discussions concerning the amount and availability of the schools' equipment. (2) For at least the past decade there has been a lively controversy concerning the effectiveness of the traditional general science approach to the teaching of junior high school science. General science is usually the course which is discontinued when earth science is adopted. (3) The next subdivision usually is concerned with the content of the course regardless of whether it is earth science or general science. (4) A large amount of material has been published concerning the origin, development, testing, comparing, and the evaluation of the various national curriculum projects and the books and programs which they have produced. A discussion of many of these programs will be found in Appendix A. Only those programs related to earth science will be discussed in this chapter.

Teacher Preparation

Almost all of the studies dealing with teachers of science relate how poorly prepared these teachers are.[1,2,3] Mallinson has stated that one of the reasons junior high school teachers are the most poorly prepared of the teachers is that once they become even moderately well prepared in any scientific discipline they are frequently transferred to the high schools, usually at their own request.[4] This is not the only factor, "Teachers have not been prepared in sufficient numbers to meet the demand because of the scarcity of college and university programs especially designed to produce teachers of earth science."[5]

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[1] Robert E. Yager, "A Junior High School Sequence in Science," School Science and Mathematics, (LXIII, December, 1963), pp. 719-725.

[2] Fred Schlessinger, "The Academic Backbone of Secondary School Science Teachers," School Science and Mathematics, (LXV, January, 1965), pp. 13-19.

[3] W. C. VanDeventer, "BSCS Materials in the Preparation of Teachers of Biology," School Science and Mathematics, (LXIV, November, 1964), pp. 683-693.

[4] George G. Mallinson, "Junior-High-School Science and the Implications of the Science Motivation Project," School Science and Mathematics, (LXIV, October, 1964), pp. 613-624.

[5] John W. Shrum, "A Proposed Curriculum for the Preparation of Earth-Science Teachers," (unpublished Doctoral dissertation, The Ohio State University, 1963), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXIV, May, 1964, Abstract No. 64-7054, (Ann Arbor: University Microfilms, Inc., 1964), p. 4576.

This is not a local problem; it is national in scope. Barfield pointed out that in Virginia many of the first-year science teachers are required to teach subjects in which they are not sufficiently trained. His study also indicated that there is a need for new science teachers to have further training in the methods of teaching. Also, many beginning science teachers apparently begin their science teaching careers without help in problem areas of teaching and in-service training. Barfield's study also indicated that first-year science teachers prefer that help and in-service assistance come from their experienced co-workers and science department heads rather than from superintendents, directors of instruction, supervisors of instruction, and principals.[1]

Gebhart found that in Montana science teachers are required to teach too many subjects in which they are inadequately prepared. In all science areas taught, the teachers lack sufficient preparation; they are best prepared in biology, least prepared in physics. All lack a sound background in geology. Gebhart recommended five years of training for science teachers, in courses tailored to meet teachers' needs, and better summer programs and graduate offerings for science teachers. Other recommendations include the elimination of science minors allied with majors in fields other than science and mathematics; more rigid supervision of teaching schedules in terms of certification requirements; and better salaries, improved teaching conditions, and more adequate facilities and equipment.[1]

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[1] Arthur Dick Barfield, Jr., "In-Service Education for Beginning Science Teachers in Virginia High Schools," (unpublished Doctoral dissertation, University of Virginia, 1961), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXII, November, 1961, Abstract No. 61-4528, (Ann Arbor: University Microfilms, Inc., 1961), pp. 1516-1517.

Lack of equipment was a problem in the teaching of science in Michigan. In his study, Bowles found that most of the major obstacles to more effective instruction which were given by the teachers related to lack of laboratory facilities and equipment, teaching load, and lack of program coordination, communication and consultant service. More senior high school teachers considered insufficient knowledge of science as an obstacle than did teachers in other types of schools.[2]

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[1] James Warren Gebhart, "The Teaching of Science in the Secondary Schools of Montana," (unpublished Doctoral dissertation, The Ohio State University, 1960), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs in Microform, XXI October, 1960, Abstract No. 60-4084, (Ann Arbor: University Microfilms, Inc., 1960), p. 799.

[2] Joseph Esmond Bowles, "A Study of Science Programs in Grades Seven, Eight, and Nine of Michigan Public Schools," (unpublished Doctoral dissertation, Michigan State University, 1964), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Micorform, XXV, March, 1965, Abstract No. 65-666, (Ann Arbor: University Microfilms, 1965), pp. 5148-5149.

A study by Batten indicated that while earth science is being taught in North Carolina, superintendents are unaware that these units are included in science textbooks in secondary schools since only eight of them reported that earth science units or concepts were being taught.[1] This would certainly influence the superintendents' decisions concerning what subject matter areas the prospective teacher should have training in. It could result in teachers being hired to teach earth science when they have had no training in this subject matter area.

In a study of teachers enrolled in in-service education programs sponsored by the State of New York, Moser found the following twelve things: (1) Twenty-two per cent of the group of elementary school teachers had no science training. (2) An average of ten semester hours of science training courses were taken by the group of teachers. (3) The likelihood of teachers to have no science training increased as there was an increase in the amount of their professional service. (4) There was a tendency for greater proportions of teachers in professional service groups to take fewer semester hours of science training as there was an increase in the years of service. (5) The teachers with no college degrees usually had taken less science training or had greater numbers of their group who took no science training than did the group of teachers holding either the bachelor's or master's degree. (6) The most common course title was methods of teaching elementary science, which was taken by 54.7 per cent of the group of 1516 teachers. General biology was the course in which the greatest number of semester hours were taken by the same group of teachers. (7) There were more definitive differences in the amounts of science training courses taken by groups of teachers arranged by levels of formal education than there were when arranged by teaching assignment. (8) Thirty-six per cent of the 5537 courses taken by the group of 1516 teachers who had some science training were in the area of biological science. Almost one-third of the courses were taken in professional education (methods of teaching science, general and elementary science). One-fifth of the courses were taken in the physical sciences and one-ninth were taken in the earth sciences. (9) Of a sample of 505 teachers who took initial science training prior to 1950, 44.2 per cent took courses again during the 1950-1961 interval. (10) Prior to 1940, three-quarters of the science training courses which were taken by the teachers were in the biological, earth, and physical sciences. During the 1950-1961 interval, the role of professional education increased to where it accounted for 45.4 per cent of the hours related to science taken by the teachers. (11) The six courses considered to be of the greatest need by the group of 1945 teachers were methods of teaching elementary science (74.9 per cent), general biology (57.4 per cent), astronomy (49.9 per cent), physical science 43.4 per cent), introductory physics (42.0 per cent), and general chemistry (39.5 per cent). (12) There were few definitive differences in opinions concerning course needs as expressed by groups arranged to stress differences in formal education, teaching assignment, and whether or not teachers had any science training.[1]

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[1] James William Batten, "An Investigation and Analysis of Laboratory Experiences in Earth Science," (unpublished Doctoral dissertation, The University of North Carolina, 1960), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXI, January, 1961, Abstract No. 60-4826, (Ann Arbor: University Microfilms, Inc., 1961), pp. 1867-1868.

The problem of improving science instruction in Nebraska was studied by Nicolai.[2]

In a study of why some teachers leave science teaching, Wise found that the quantity and quality of the current high school science teacher leaves much to be desired. He also found that the loss of science teachers is primarily due to the brighter future in other areas of employment and inadequate salaries. Furthermore, increased salaries were specified as the major factor needed to retain the current science teachers and for the return of former science teachers. The data and comments reported by Wise revealed the immediate need for a great many improvements. These improvements are modest and most realistic when compared to the status of other professions and with what labor unions have obtained for the non-professional worker. Gains must be granted in salary and working conditions if the exodus from science teaching is to be stopped. These would help eliminate the shortage of science teachers, both in number and quality. Only by the elimination of our science teacher shortages will our youth be adequately educated in science for their citizenship responsibilities and for the stimulation needed to increase their desire for a scientific or engineering career.[1]

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[1] Gene Wendell Moser, "The Post-Secondary Science Training of One Thousand Nine Hundred and Forty-Five New York State Elementary School Teachers," (unpublished Doctoral dissertation, Cornell University, 1964), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXV, January, 1965, Abstract No. 65-3329, (Ann Arbor: University Microfilms, Inc., 1965), p. 4564.

[2] Frederick Lawrence Nicolai, "Some Principles and Supervisory Techniques for the Improvement of Science Instruction," (unpublished Doctoral dissertation, The University of Nebraska, 1960), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXI, December, 1961, Abstract No. 60-4507, (Ann Arbor: University Microfilms, Inc., 1961), pp. 1471-1472.

Even more important, the quantity of competent teachers in the nation's schools will determine whether or not the next generation understands the import of the earth sciences well enough to live intelligently in an age of science.[1]

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[1] Ernest George Wise, "An Investigation of the Stated Reasons Why Some Teachers Leave Science Teaching, Where They Go, and How They Might Have Been Retained," (unpublished Doctoral dissertation, Syracuse University, 1960), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXI, March, 1961, Abstract No. 61-530, (Ann Arbor: University Microfilms, Inc., 1961), pp. 2541-2542.

The importance of well prepared science teachers was presented by Pennington. He reported that larger percentages of students interested in science than expected reported that their interest in science had been stimulated by good teaching. Enthusiastic, well prepared teachers, who took a personal interest in their students, provided opportunities for participation in activities during and after school hours favorably influenced students' interest in science. Students were more likely to be interested in science if they had the opportunity of working in well equipped laboratories.[2]

The importance of good science teaching was also presented by Welch. He found that the order of importance of persons who first interested practicing scientists in science was teacher, self-interest, father, relative, young friend, mother, adult friend. He also found that the persons who *most* interested practicing scientists in science were, in the order of their importance; teacher, self-interest, father, adult friend, relative, young friend, and mother. Character traits of influential teachers were reported. [1] It would thus appear that if an interest in science is to be stimulated in today's students, good teaching is the essential ingredient, followed by well equipped laboratories.

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[1] William M. Merrill and John W. Shrum, "Planning for Earth Science Teacher Preparation," *Journal of Geological Education*, (XIV, February, 1966), p. 25.

[2] Tully Sanford Pennington, "A Study of Factors Which Affected High School Seniors' Interest in Science" (unpublished Doctoral dissertation, The Florida State University, 1960), quoted from *Dissertation Abstracts: A Guide to Dissertations and Monographs Available on Microform*, XX, May, 1960, Abstract No. 60-1415, (Ann Arbor: University Microfilms, Inc., 1960), p. 4344.

General Science or Earth Science and Course Content

The debate between the advocates of general science[2,3,4] and the advocates of the specific scientific disciplines[5,6] for each grade of junior high school is in reality a debate as to how to best do what both groups want to do. Both want to teach science better and to show the interrelated nature of all disciplines of science. Thus, it boils down to a debate of what and when.[1,2,3,4,5,6,7,8] One of the things that this debate seems to indicate is that general science is an out-dated course which is a contributing factor to the decline in the interest in science that takes place during the

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[1] Ellsworth William Welch, "Motivational Factors In Choice of Profession by American Scientists," (unpublished Doctoral dissertation, Stanford University, 1959) quoted from *Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform*, XX, October, 1959, Abstract No. 59-3675, (Ann Arbor: University Microfilms, Inc., 1959), pp. 1233-1234.

[2] Abraham S. Fischler, "Science for Grades Seven, Eight, and Nine," *School Science and Mathematics*, (LXI, April, 1961), pp. 271-285.

[3] Abraham S. Fischler, "Junior High School Science," *School Science and Mathematics*, (LXIV, January, 1964), pp. 21-30.

[4] Sam S. Blanc, "New Directions in Junior High School Science," *School Science and Mathematics*, (LXIV, April, 1964), pp. 282-284.

[5] Lorenzo Lisenbee, "Teaching Science to the Slow Learner--The BSCS Point of View," *School Science and Mathematics*, (LXV, January, 1965), pp. 39-46.

[6] Loren T. Caldwell, "Earth Sciences in the Ninth Grade," *The Science Teacher*, (XXV, October, 1958), pp. 337-341.

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[1] Donald H. Lokke, "Objectives in Pre-College Geological Education," GeoTimes, (VII, November-December, 1962), pp. 18-20, 43.

[2] H. Seymour Fowler, "Some Trends in Secondary School Science Education," Science Education, (XLIX, March, 1965), pp. 183-184.

[3] Norman D. Anderson and Walter R. Brown. "What Does the Future Hold for Junior High Science," School Science and Mathematics, (LXI, April, 1961), pp. 239-241.

[4] Charles H. Heimler, "General Science in a State of Flux," School Science and Mathematics, (LXIV, December, 1964), pp. 755-764.

[5] John M. Chapman and Loren T. Caldwell, "A Content Study of Earth Science Courses in Selected Secondary Schools," Science Education, (XLVIII, December, 1964), pp. 430-435.

[6] H. Clark Hubler, "Reshaping the Curriculum in a World of Science," Science Education, (XLVIII, March, 1964), pp. 117-120.

[7] Loren T. Caldwell, "Earth and Space Science in the K-12 Science Program," School Science and Mathematics, (LX, March, 1960), pp. 207-213.

[8] Cyrus W. Barnes, "A Definition of Science Education: Curriculum Research," Science Education, (XLV, December, 1961), pp. 394-396.

the junior high school years.[1]

Schmidt states that general science has become a haphazard scramble of "science" with no continuity, no focus, no building and no unity with integrating themes. Often it could better be classed as technology. Almost any teacher will attempt to teach the course and feels safe in doing so.[2]

There is evidence that interest and learning is stimulated when earth science is substituted for general science.[3]

Toohey found that the earth science course of study is significantly superior to the general science course of study for increasing ninth-grade student achievement of science subject matter and the ability to read and comprehend science subject matter. A course of study in earth science should, therefore, replace the present ninth-grade general science course.[4]

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[1] Mallinson, p. 614.

[2] Donald Schmidt, "Attempts with Curriculum Design in the Secondary School," School Science and Mathematics, (LXV, June, 1965), pp. 568-572.

[3] Hugh M. Davison and H. Seymour Fowler, "Earth Science Course Evaluation: What do They Learn in Earth Science?" Science Education, (XLIX, March, 1965), pp. 184-185.

[4] Jack Vincent Toohey, "The Comparative Effects of Laboratory and Lecture Methods of Instruction in Earth Science and General Science Classes," (unpublished Doctoral dissertation, Arizona State University, 1963), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXIV, February, 1964, Abstract No. 64-2194, (Ann Arbor: University Microfilms, Inc., 1964), p. 3241.

One frequently cited objection to the introduction of an earth science course is that high schools should concentrate on providing the foundations in mathematics, chemistry, physics, and biology; other sciences should not be offered to compete. However, with the decline of general science, the offering of its content in earlier grades, earth science courses do not compete but offer a most logical alternative. Perhaps to a greater degree than any other science, earth science provides the student with knowledge and a framework within which he may develop his understanding of the earth as man's environment. The examination of chemical, physical, and biological aspects of the earth, if properly presented, should help spark student interest in undertaking additional study in these fields. As other sciences are presented in succeeding years, earth science provides a basis for the understanding of how they related to one another as well as to the earth. Further, approximately 60 per cent of the high school students do not take any physical science beyond ninth-grade. For these, earth science provides their only formal study of the concepts, materials, and processes of the physical sciences.[1]

In short, an integrated earth science course provides perspective with which to view the earth, the solar system, the universe, and the plant and animal kingdoms, including man, in space and time.[1]

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[1] Merrill and Shrum, p. 23.

Regardless of whether the approach is that of earth science or general science, there is general agreement that much must be done to strengthen the presentation of science in the junior high school.[2]

Heimler's study indicated that the need for strengthening science programs is especially apparent in grades seven, eight, and nine. There is a significant lack of science demonstration and laboratory work in these grades, and a lack of adequate science facilities and equipment. Science teaching consists, in a large part, of the reading, writing, and talking about science with a minimum of experience with scientific methods and science materials.[3]

Murphy's study indicated that the basic factor for the initiation of the actions to improve the high school science curriculum was the concern for scientific manpower needed for national defense and economy. The major factors in determining the nature of the changes appeared to be the policies of the federal government, the scientific community outside the pubic school group, and the private foundations.[1]

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[1] *Ibid.*, p. 23.

[2] Gary Walter Nahrstedt, "An Analysis of the Junior High School Science Program, with Proposed Guides for Curriculum Revision," (unpublished Doctoral dissertation, Auburn University, 1963), quoted from *Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform*, XXIV, February, 1964, Abstract No. 64-1539, (Ann Arbor: University Microfilms, Inc., 1964), pp. 3233-3234.

[3] Charles Herbert Heimler, "A Guide for Science Supervision in the New York State Central School," (unpublished Doctoral dissertation, New York University, 1949), quoted from *Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform*, XX, April, 1960, Abstract No. 60-1091, (Ann Arbor: University Microfilms, Inc., 1960), pp. 3999-4000.

National Curriculum Projects

Most of the major national curriculum projects which are related to science are described in Appendix A. The older the curriculum project is, the more thoroughly it has been tested and examined in the literature. Most of the studies deal with one or more of the new mathematics programs,[2] with PSSC physics,[1,2,3] and with the BSCS biology program.[4]

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[1] Earl Paulus Murphy, "A Study of Probable Factors Influential in Affecting the Futuure Science Curriculum of the Secondary Schools in the United States," (unpublished Doctoral dissertation, St. Louis University, 1960), quoted from Dissertation Abstracts: A Guide to Dissertations and Monographs Available in Microform, XXI, April, 1961, Abstract No. 61-764, (Ann Arbor: University Microfilms, Inc., 1961), pp. 2948-2949.

[2] R. J. Diamond, "A Commentary Inspired by the New Mathematics Programs," School Science and Mathematics, (LXIII, November, 1963), pp. 658-664.

Statewide Curriculum Studies

Texas is not the only state which has experimented with the introduction of earth science into the curriculum. Other states have also experimented with this subject matter area. Three of the most active states in this field have been New York, Pennsylvania, and New Jersey. Among the other states which have experimented with instruction in earth science is Oklahoma. An experimental program was tried out there in the summer of 1958 with seventeen junior high school students.[5]

Coash reported that in 1962 earth science courses were being offered in the schools of 39 states. Pennsylvania and New York lead in the number of schools offering these courses

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[1] (Robert H. Carleton), "PSSC versus Conventional Physics," The Science Teacher, (XXIX, February, 1962), p. 47.

[2] Oscar L. Brauer, "Conventional Physics Against PSSC Physics," Science Education, (LXIX, March, 1965), pp. 170-171.

[3] Lawrence Gene Poorman, "Indiana Physics Teachers React to PSSC," Science Education,(LXIX, March, 1965), pp. 171-172.

[4] Lorenzo Lisenbee and Bill J. Fullerton, "The Comparative Effect of BSSC and Tradiational Biology on Student Achievement," School Science and Mathematics, (LXIV, October, 1964), pp. 594-598.

[5] Jerome M. Pollack, "Junior High Geology," GeoTimes, (III, January-February, 1959), p. 10.

with 400 and 450 schools respectively.[1]

A survey made by the Earth Science Curriculum Project staff in July, 1963, indicated that schools in all 50 states and the District of Columbia planned to offer courses in earth science during 1963-64. The number of schools ranged from one or two in Mississippi to 683 in New York State. By far the most ambitious earth science programs have been undertaken in New York, New Jersey, and Pennsylvania. In 1962-63, more than 118,111 students took earth science courses in 1,325 schools in these states alone. These three states account for 62 per cent of the known earth science enrollment in the United States.[2]

Geology, or its close relative physical geography, was widely taught in the United States in the earlier years of this century. In the early 1920's general science began to displace these subjects. Throughout the years of declining enrollments, New York State, recognizing the cultural and practical values of physical geography continued to recommend it as an elective. In 1939 the state syllabus was revised to meet the changing needs of modern times, and the name was changed to earth science. The pupils who continued to take this course were usually in the tenth-, eleventh-, or twelfth-grade and went to one of the about one hundred high schools that taught it.

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[1] John R. Coash, "Earth Science in the Secondary Schools," GeoTimes, (VII, March, 1963), pp. 26--29.

[2] William H. Matthews, III, "Current Status of Earth Science Programs in Secondary Schools," ESCP Newsletter, (NL-2, January, 1964), pp. 1-3.

In 1949 an experiment designed to take care of individual differences in interest and aptitude for science was begun in one school. Carefully selected science-minded ninth-grade pupils took earth science rather than the regular ninth-grade general science. The results were so satisfactory that the school continued the program during the succeeding years.

In most cases the teaching of the earth science courses, which developed from the experimental course, is being done by regular general science teachers or by other members of the science department even though their training had been in some other field of science. At first a teaching certificate in general science or in the physical sciences was sufficient to teach earth science. Effective September 1, 1958, earth science was included with the other sciences as a separate subject for certification.[1]

This experiment indicates that earth science is growing more popular as a non-major subject. Many non-science majors will enroll in earth science courses for their scientific content and for cultural enrichment.[1]

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[1] Donald B. Stone, "Earth Science," GeoTimes, (II, January, 1958), pp. 8-9.

The success of this experiment is illustrated by the following figures showing the growth of earth science in the State of New York. In 1951-52, 15 schools offered 22 ninth-grade classes to 503 students, and 121 schools offered 352 twelfth-grade classes to 9,993 students. In 1961-62, 420 schools offered 631 ninth-grade classes to 16,223 students, and 159 schools offered 601 twelfth-grade classes in earth science to 33,484 students.[2]

In 1958 the Pennsylvania Department of Public Instruction decided that it would be beneficial for all future citizens to learn more about the earth on which they live and the realm of space to which their future lives will be increasingly oriented. At that time a small amount of geology, meteorology, and astronomy was being taught in a series of seventh-, eighth-, and ninth-grade general science courses. The new idea called for the consolidation and expansion of this material into a one-year-long science course.

Because there were no specialists in these areas in the Department of Public Instruction, Dr. Lee Boyer, Scientific Consultant, organized a volunteer fourteen-man advisory committee to develop an earth and space science course which would include the principles of geology, meteorology, and astronomy. Four geologists, three astronomers, one meteorologist, one space scientist, one geographer, one conservationist, one earth scientist, and two high school teachers were appointed to this advisory committee. A sub-committee of two geologists, two astronomers, and one meterologist set about developing the course philosophy and preparing the syllabus. The subcommittee decided upon the folowing things: (1) the original syllabus should be pitched for gifted college-bound students and later adapted for less talented classes; (2) the identity of the disciplines of geology, meteorology, and astronomy should be maintained, but the relationship between the three disciplines should be clearly spelled out; (3) the teaching order of geology-meteorology-astronomy is probably the most logical because the student is taken from his known surroundings outward into space, with space travel saved for last; (4) the student should be well exposed to the uncertainties and unsolved problems in these sciences and should be dissuaded from the idea that science already has solved most of the problems in these fields; and (5) the student's curiosity should be stimulated by concentrating on explanations of natural phenomena not merely on descriptions to be memorized.

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[1] Claude E. Gatewood, "Impact Ahead," GeoTimes, (VII, January-February, 1963), pp. 8-12.

[2] "Explosive Development of Earth Science Courses," Donald B. Stone, "Growth of Earth Science in New York State," GeoTimes, (VII, October, 1962), pp. 13-15.

It took nine months for the subject matter outline to be completed and approved by the full committee. A teachers' guide was published by the Pennsylvania Department of Public Instruction. The problem of obtaining qualified teachers for this new course was met by the establishment of teacher certification requirements. However, these new requirements will not completely solve the serious shortage that exists in qualified earth science teachers.[1]

In 1961-62 more than 400 Pennsylvania schools taught earth science to 38,000 students.[2,3]

In January, 1962, the New Jersey State Department of Education surveyed the 495 accredited public and private schools of the state in an effort (1) to determine the number of schools in which an earth science course was taught during the 1961-62 school year; (2) to compare the number of schools offering courses in earth science, and the total number of pupils enrolled in these courses, for the school years 1956-57, 1960-61, and 1961-62 respectively; (3) to obtain information about the grade placement, textbooks used, total minutes per week of classroom and laboratory instruction, total number of class sections, total number of pupils enrolled, identity of earth science teachers, and comments concerning the earth science programs taught in New Jersey secondary schools during the 1961-62 academic year; and (4) to ascertain the nature and extent of the background preparation in science, and in particular earth science, of the teachers of these earth science courses.

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[1] John H. Moss, "Revival of Geology in Pennsylvania High Schools," GeoTimes, (III, May-June, 1959), pp. 18-19.

[2] Robert E. Boyer and John L. Snyder, "Teachers of Earth Science," GeoTimes, (VIII, March, 1964), pp. 13-16.

[3] "Explosive Development of Earth Science Courses," John E. Kosoloski, "The Pennsylvania Earth and Space Science Program," GeoTimes, (VII, October, 1962), pp. 15-17.

It was found that earth science was taught in 12 schools in 1956-57, 38 schools in 1960-61, and 72 schools in 1961-62. It was taught in 18 of the 21 counties of New Jersey, and was offered by one out of seven secondary schools in the state. It was taught most frequently at the ninth-grade level. The typical school offering earth science courses had three sections of about twenty-five students each, and selected students for the program according to ability. Earth science was taught for five periods a week, with little or no time devoted to laboratory experiences. Most schools used Earth Science: The World We Live In by Namowitz and Stone or Modern Earth Science by Ramsey and Burckley.

Only one-half of the earth science teachers held permanent New Jersey teaching certificates, and only one-half of those with certificates were properly certified to teach earth science. Slightly more than one-half had taken one or more courses in geology, about one-third had completed course work in astronomy or meteorology, and only about one-tenth had studied oceanography. Twenty per cent of the teachers reported that they had not earned a single credit in any of the earth sciences, and sixty-nine per cent had fewer than nine total credits in the earth sciences.

Two facts are immediately apparent from this New Jersey study: (1) there has been a tremendous increase in the number of earth science courses taught (600 per cent) between 1956-57 and 1961-62, and (2) a high percentage of the teachers assigned to this course are inadequately prepared to teach it.[1]

From the foregoing it should be obvious that the earth science programs of Pennsylvania and New York were instigated by the state departments of education. On the other hand, in New Jersey the programs apparently grew out of work done by local school people, and which was later investigated by the state authorities.

One of the reasons for this pattern of growth which took place in New Jersey could have been the Junior High School Science Project at Princeton University. The earth is the central theme of the course which is being developed by Princeton, but its content includes much physics and chemistry.[1]

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[1] "Explosive Development of Earth Science Courses," Dean M. Laux, "Earth Science Courses in New Jersey and the Qualifications of Teachers," GeoTimes, (VII, October, 1962), pp. 17-19.

The curriculum Time, Space, and Matter: Investigating the Physical World[2] consists of three parts: Part I "On the Nature of Things," Part II "Seeking Regularity in Matter," and Part III "Interpreting a World of Change." There is no formal textbook; the students record their observations and measurements in a Student Record Book.[3] These record books, one for each of the three major parts of the course, are comprised mostly of empty pages upon which the student himself must set up his own tables for the systematic recording of data. Thus, the course is almost entirely a laboratory course from which the student learns primarily from his own discoveries. Each student receives a kit of the materials he will need to conduct his experiments.[4]

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[1] Using Current Curriculum Developments, (Washington: Association for Supervision and Curriculum Development, NEA, 1963), p. 67.

[2] Secondary School Science Project, Time, Space, and Matter: Investigating the Physical World, Teacher's Text--Series I, II, and III, (Princeton: Princeton University, 1964).

[3] Secondary School Science Project, Time, Space, and Matter: Investigating the Physical World, Student Record Book--Series I, II, and III, (Princeton: Princeton University, 1964).

[4] Horace MacMahan, "Princeton Project or ESCP: A Difficult Choice," School Science and Mathematics, (LXIV, January, 1966), pp. 86-91.

Earth Science Curriculum Project

The initial step toward developing earth science materials for elementary and secondary schools was taken by the American Geological Institute (AGI) in 1958, when the institute appointed a Steering Committee to organize and plan a six-weeks teaching resource development conference. This conference, now formally known as the Duluth Conference, was held on the campus of the University of Minnesota, Duluth, in the summer of 1959. At this conference a source book for teachers was produced by a group of 32 writers. This sourcebook was published by Holt, Rinehart and Winston, Inc., in 1962 as the *Geology and Earth Sciences Sourcebook for Elementary and Secondary Schools*. Encouraged by its initial effort, the AGI decided to initiate a major interdisciplinary course-content improvement program in the earth sciences. Funds to support the initial phase of the project, formally designated the Earth Science Curriculum Project (ESCP), were granted by the National Science Foundation early in 1963.

Shortly thereafter, a Steering Committee, consisting of scientists and science educators, established broad guidelines for the project and developed a set of themes designed to unify the materials produced by ESCP writing teams. A planning conference of scientists, secondary school teachers, and educators was held in the summer of 1963, and another in December of the same year, to develop detailed outlines for an earth science course of study.[1]

Armed with these outlines, a group of 41 writers assembled at Boulder on June 22, 1964, to begin work on the course. Before the end of the summer they had produced the first edition of a textbook, a teacher's guide, and a laboratory manual.

A Teacher Briefing Session was held on the campus of the University of Colorado from August 17 until August 21, 1964. Dr. John W. Shrum, ESCP Director of Teacher Preparation, organized and directed the session. Ninety-five persons, most of whom were involved in the evaluation of the ESCP materials, attended the briefing session. Of the 95 there, 77 were official ESCP teachers from 15 test centers located in various sections of the United States. In addition, 15 college consultants, one for each test center, were also present to learn their responsibilities in the evaluation program.

The session was held to brief the teachers on the content and procedures that they were to use during the 1964-65 school year. In the experimental use of new materials for teaching earth science in the secondary schools, a prime requisite is that the teacher be familiar with both the subject matter and the methods for presenting it. He also needs to understand what the student should be able to do as a result of using ESCP materials. Consequently, the objectives of the briefing session were not unlike those the teacher would be having for his students.

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[1] American Geological Institute, Investigating the Earth, Teacher's Guide, Robert L. Heller and Chalmer J. Roy, "Forward," (Denver: American Geological Institute, 1964), p. v-vi.

The major objectives of the briefing session were: (1) to familiarize the teachers with the concepts stressed in the textbook Investigating the Earth, (2) to discover and recognize student experiences that will contribute to conceptual understandings, (3) to recognize the unity and interrelationships of the scientific concepts being presented, and (4) to become familiar with procedures that will result in the accumulation and communication of data needed to evaluate the materials and methods used.[1]

One of the fifteen test centers for the 1964-65 Evaluation Program was at Dallas, Texas. The Center Consultant was James Brooks of Southern Methodist Univeristy. The five schools comprising the test center were St. Mark's School of Texas, Dallas; Vivian Field Junior High School, Dallas; Sam Houston Junior High School, Garland; Lancaster High School, Lancaster; and Sunnyvale Junior High School, Mesquite.[2]

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[1] "Teacher Briefing Session Begins Experimental Use of ESCP Materials," ESCP Newsletter, (NL-5, October, 1964), p. 2.

[2] "ESCP Announces Evaluation Program," ESCP Newsletter, (NL-3, April, 1964), pp. 7-9.

In any experimental program, testing is an important aspect. The students, in both the experimental and control classes, were given beginning-of-the-year tests, periodic achievement tests, end-of-the-year tests, and the Verbal Reasoning and Numerical Ability subtests of the Differential Aptitude Test.[1] The Psychological Corporation constructed special tests for the ESCP and selected the control group of students.[2] Additional information, feed-back, was furnished the ESCP in the weekly reports of the teachers and from visitation reports of the consultant.

All of this information was made available to the writers who assembled on June 22, 1965, on the campus of the University of Colorado to revise the first edition of the textbook, teacher's guide, and laboratory manual.[3]

The revised materials are now being tried and tested in 15 test centers. Some of the old centers are being used for the second year, but some have been changed to see if any differences would be found between the old and new test centers. Texas again has one of the centers, but the ESCP selected Texas as one of the places where they would try a new center. Houston was selected, and the Center Consultant is DeWitt C. Van Siclen of the University of Houston. The five schools comprising the test center are Ezekiel Cullen Junior High School, Houston; Jesuit College Preparatory School, Houston; South Houston Intermediate School, South Houston; Albert S. Johnson Junior High School, Houston; and Spring Woods Junior High School, Spring Branch.[1]

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[1] G. K. Bennett, H. S. Seashore, and A. G. Wesman, The Differential Aptitude Tests, Form L. (New York: The Psychological Corporation, 1963).

[2] Wimburn L. Wallace, "The ESCP Program of Objective Testing," ESCP Newsletter, (NL-7, April, 1965), pp. 4-6.

[3] "Summer Writing Conference," ESCP Newsletter, (NL-7, April, 1965), p. 1.

The text and materials of the ESCP are different from the traditional approach to earth science. These materials have a unifying scheme built around two major aspects of earth science: the hydrologic cycle and the rock cycle or petrogenic cycle. From these two themes oceanography, meteorology, astronomy, and geology can be taught and interrelated.[2]

The American Geological Institute has a companion program with the ESCP. In 1962 the AGI set up the Geological Education Orientation Study (GEO-Study) in response to increasing criticism of education in geology and to determine what direction improvements should take if any were needed.

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[1] "1965-66 Evaluation Program," ESCP Newsletter, (NL-7, April, 1965), pp. 8-10.

[2] Chalmer J. Roy, "The Challenges of ESCP," ESCP Newsletter, (NL-4, July, 1964), pp. 1-6.

Teams were sent to the various colleges and universities teaching geology to learn more about their programs and to evaluate them in terms of the criticisms which had been voiced.[1]

These visits to the colleges brought to light that more secondary school teachers of earth science were needed than professional earth scientists. To meet this need a Panel on the Preparation of Earth Science Teachers was appointed. This Panel was continued under the Council on Education in the Geological Sciences (CEGS) when that body replaced the GEO-Study group.[2]

Both the ESCP and the CEGS Panel are very active in trying to improve the education of earth science teachers and in the recruitment of more and better prepared teachers for the rapidly expanding number of secondary school earth science classes.

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[1] "GEO-Study," GeoTimes, (VI, May-June, 1962), pp. 18, 19, and 49.

[2] Merrill and Shrum, p. 24.

CHAPTER III

PROCEDURE

READABILITY DETERMINATIONS

The problem of determining the reading difficulty of the textbooks adopted for use in the eighth-grade science classes of the public schools of Texas was broken down into the following two questions:

> Were the earth science textbooks, which were adopted by the State of Texas, written at a reading level which could be understood by more than half of the students using them?
>
> Are there other textbooks that perhaps should be adopted, in addition to those now adopted, for use in the eighth-grades of Texas?

As the work progressed, two other questions seemed to be worthy of consideration. The questions were:

> How does the reading level of the adopted earth science textbooks compare with the reading level of the two general science textbooks that were also adopted for use in the eighth-grade?
>
> How does the reading level of eighth-grade textbooks compare with the reading level of an earth science textbook specifically written for use in college classes?

The following textbooks were selected for examination: Basic Earth Science by MacCracken and others, Earth Science: The World We Live In by Namowitz and Stone, Modern Earth

Science by Ramsey and Burckley, Modern Science by Blanc and others,[1] and Science is Understanding by Beauchamp and others,[2] these books all being the ones adopted for use in eighth-grade science classes; Exploring Earth Science by Thurber and Kilburn,[3] a new textbook that appeared to be suitable for use in eighth-grade earth science classes; and The Earth Sciences by Strahler,[4] an earth science textbook written for use in college earth science classes. The first and second editions of the Earth Science Curriculum Project textbook Investigating the Earth were not examined because readability analyses had already been made of them.

The procedure for determining the readability of these seven books was the one published by Dale and Chall. The same procedure was used for each book.

The analysis started on page 10 and was made on every tenth page thereafter. If a page selected contained less than 100 words, was blank, or contained a picture, figure, or table, the next page that contained 100 or more words of text was used. The passage selected for analysis started with the first sentence of the first paragraph that began on the page to be sampled. There was one exception to this procedure. If the 100 word sample from the first paragraph ended on the page following the one to be sampled, a different sample selection was made. In this case the first complete sentence on the page started the sample. This was done even though the sample included the end of one paragraph and the beginning of another. This way the sample to be analyzed could be kept entirely on the page selected for analysis.

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[1] Sam S. Blanc, Abraham S. Fischler, and Olcott Gardner, Modern Science 2 (New York: Holt, Rinehart and Winston, Inc., 1963).

[2] Wilbur L. Beauchamp, John C. Mayfield, and Paul DeHart Hurd, Science is Understanding (Chicago: Scott, Foresman and Company, 1964).

[3] Walter A. Thurber and Robert E. Kilburn, Exploring Earth Science (Boston: Allyn and Bacon, Inc., 1965).

[4] Arthur N. Strahler, The Earth Sciences (New York: Harper and Row, Publishers, 1963).

Most of the samples contained more than 100 words, because all passages ended with the end of the sentence containing the one-hundredth word. Only complete sentences were used.

After the sample was selected, the number of words in the sample was recorded as Item No. 1 on the data sheet.

The number of sentences in the sample were then counted. The number of sentences was recorded as Item No. 2 on the data sheet.

The unfamiliar words, those not on the Dale List of 3,000 words, were then marked, counted, and recorded as Item No. 3 on the data sheet.

Next, the average sentence length was determined by dividing the number of words in the sample by the number of sentences in the sample. This information was recorded as Item No. 4 on the data sheet.

The Dale score was calculated by dividing the number of words not on the Dale list by the total number of words in the sample. The score was noted as Item No. 5 on the data sheet.

The average sentence length, Item No. 4, was then multiplied by 0.0496 and the product recorded as Item No. 6. The Dale score, Item No. 5, was multiplied by 0.1579, and the answer was recorded as Item No. 7. These two numbers were added together and then added to the constant 3.6365 and the sum was recorded as Item No. 9. The sum represented the raw score of the sample. From a table, the raw score was converted into the grade level of readability of the passage. When all samples of the book had been analyzed and checked, the raw scores were added together and averaged. The resulting number gave the average raw score of the book. The score was converted by means of a table presented by Dale and Chall, see Table 3, into the average reading level of the book.

The reading scores were grouped together by chapters and the average reading level of each chapter was then determined. The average reading level score for each chapter was plotted on a graph to show the variations in reading level within each book.

The easiest selection and the most difficult selection are shown as Figures 3 and 4, with the unfamiliar words underlined. The data sheets showing the reading level determinations are shown as Tables 4 and 5. The table presented by Dale and Chall to obtain the grade placement of the reading level is shown as Table 3. From these tables and figures it can be observed that the passage with the lower reading level contains fewer unfamiliar words and shorter sentences than the passage with the higher reading level.

FIGURE 3

PASSAGE WITH LOWEST READING DIFFICULTY SCORE[1]

The oil is allowed to flow away through pipes into large steel tanks. Some wells flow for a while, but stop when the gas pressure is no longer great enough to push the oil up and out. Then the wells are pumped until they are dry. No new oil is formed in the rock below. Oil geologists can never tell how long a well will produce. Some wells have been pumped for several years. Others cease producing in a short time. Many wells are often drilled into the same pool to draw off the oil more rapidly. In a big oil field the derricks are almost as thick as trees in a forest.

In this passage there are 113 words in 9 sentences. The six words underlined are not on the Dale list, and the sentences average 12 words. The raw score is 5.02 which gives a reading grade placement of 5-6 grade.

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[1] Helen D. MacCracken, Donald G. Decker, John G. Read, and Alton Yarian, Basic Earth Science (Syracuse: The L. W. Singer Company, 1964), p. 110.

TABLE 4

SAMPLE WORK SHEET FOR THE DALE-CHALL FORMULA

Article: Basic Earth Science	Page No. 110	Page No.
Author: MacCracken, Decker, Read, Yarian	From The oil	From Chapter 5
Publisher: The L. W. Singer Company Date: 1964	To forest.	To
1. Number of words in the sample	113	
2. Number of sentences in the sample	9	
3. Number of words not on the Dale list	6	
4. Average sentence length (divide 1 by 2)	12	
5. Dale score (divide 3 by 1, multiply by 100)	5	
6. Multiply average sentence length (4) by 0.0496	0.5952	
7. Multiply Dale score (5) by 0.1579	0.7895	
8. Constant	3.6365	3.6365
9. Formula raw score (add 6, 7, and 8)	5,0212	

Average raw score of 1 sample 5.0212 Analyzed by: L. E. K. Date: 11/26/65

Average corrected grade-level 5 - 6 Checked by: E. H. K. Date: 11/27/65

FIGURE 4

PASSAGE WITH HIGHEST READING DIFFICULTY SCORE[1]

Carbonate strata, or limestones, composed of carbonates of calcium and magnesium,are highly susceptible to the action of carbonic acid produced by the solution of atmospheric carbon dioxide in soil and ground water (see Chapter 26). As infiltrating precipitation passes downward through the zone of aeration to reach the ground-water zone in which it moves slowly toward effluent zones in stream valleys, large quantities of limestone are removed in solution, leaving a system of interconnected tubes and rooms which we call a cavern system. Although caverns can form in limestones of folded and faulted strata and in metamorphic carbonate rock (marble), it is appropriate to treat cavern development along with horizontal strata because of the simplicity of the geological structure.

In this passage there are 116 words in 3 sentences. The 45 words underlined are not the Dale list, and the sentences average 39 words. The raw score is 11.73 which gives a reading grade placement of 16+, which is college level of reading difficulty. The words in parentheses were not included in the sample nor were they counted.

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[1] Arthur N. Strahler, The Earth Sciences (New York: Harper and Row, Publishers, 1963), p. 581.

TABLE 5

SAMPLE WORK SHEET FOR THE DALE-CHALL FORMULA

Article: The Earth Sciences	Page No. 581	Page No.
Author: Strahler	From Carbonate	From Chapter 33
Publisher: Harper and Row Date: 1963	To structure.	To
1. Number of words in the sample......................	116	
2. Number of sentences in the sample..................	3	
3. Number of words not on the Dale list...............	45	
4. Average sentence length (divide 1 by 2)............	39	
5. Dale score (divide 3 by 1, multiply by 100)........	39	
6. Multiply average sentence length (4) by 0.0496.....	1.9344	
7. Multiply Dale Score (5) by 0.1579..................	6.1581	
8. Constant...	3.6365	3.6365
9. Formula raw score (add 6, 7, and 8)................	11.7290	

Average raw score of 1 sample 11.7290 Analyzed by: L. E. K. Date: 11/27/65

Average corrected grade-level 16+ Checked by: E. H. K. Date: 11/28/65

TEACHER PREPARATION AND EQUIPMENT STATUS OF TEXAS SCHOOLS

The problem of determining how well the teachers were prepared and how well the schools were equipped to present a course in earth science was broken down into the following three questions:

> Have the eighth-grade teachers had a sufficient number and variety of science courses, particularly earth science courses, to teach this new material?
>
> Are the schools which have eighth-grades adequately equipped for the presentation of this new material?
>
> To what extent have the schools of Texas replaced general science with earth science?

Method of Sampling

It was decided that a questionnaire would be the most effective way to obtain the information needed to answer the three questions just presented.[1]

The names of the public schools of Texas can be found in the Public School Directory which is published annually by the Texas Education Agency. This book tells what grades are taught within each school district. It also lists the schools by name, gives the name of the principal of each school, and the name of the superintendent and his office address. It does not give the addresses of the individual schools, nor does it tell which grades are taught within each individual school. This information can only be obtained from the accreditation forms which are filed by the individual schools with the Texas Education Agency.

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[1] Carter V. Good, A. S. Barr, and Douglas E. Scates, The Methodology of Educational Research (New York: Appleton-Century-Crofts, Inc., 1935), pp. 324-325.

These forms provide for only two types of schools. These are elementary schools which can contain the first- through eighth-grades, and secondary schools which can contain the seventh- through twelfth-grades. However, the Texas school districts are not always organized along the lines called for by the accreditation forms. In some districts they are organized according to the space that is available within individual school buildings. As a result, the organization changes as the school population changes. The districts can have primary, elementary, intermediate, junior high, and senior high schools in any combination they choose. This organization of the schools makes it extremely difficult to locate the particular schools which house eighth-grades. This information can be obtained only by a thorough search of the school accreditation files in the Texas Education Agency in Austin, Texas. This is a slow process because these files are not set up for either mechanical or electronic data retrieval. The time available between the adoption of the textbooks and the close of school was not sufficient for such a search.

Because of these limitations, the Public School Directory appeared to be the only available mailing list. As a result, the method which was used for sampling had to meet three conditions: (1) it had to be one which would guarantee that a reasonable number of questionnaires would actually reach eighth-grades, (2) it had to guarantee that those which reached eighth-grades would be returned in sufficient numbers to produce usable information, and (3) all of this had to be accomplished within the short time available between the adoption of the textbooks and their first use in earth science classes in the Texas public schools.

Because the schools listed in the Public School Directory were arranged by counties, and because the accreditation files of the Texas Education Agency were kept by counties, the county became the basis of sampling. Because the junior high school was the most likely place to find the eighth-grade, the questionnaires were sent to the junior high schools. If no junior high school existed within the district, the questionnaire was sent to an elementary school. Most of the counties were sampled by sending four questionnaires to that county. Two questionnaires went to the largest districts. Two questionnaires went to the smallest districts. The junior high school in the largest district and the junior high school in the second largest district each received a questionnaire. The junior high school in the smallest district and the junior high school in the second smallest district each received a questionnaire. If there were more than one junior high school in the district, the school to be sampled was chosen by dividing the schools of the district into groups of six or less and by assigning each school in the group a number from one to six. The junior high school to receive the questionnaire was selected by the roll of die.[1]

In order to better guarantee a return from the more populous counties, in some cases the three largest and the three smallest districts were sampled. In metropolitan areas, where there were many junior high schools, a questionnaire was sent to each junior high school within each group of six junior high schools. As before, the school in each group was selected by the roll of a die.

This large number of questionnaires was used in the first mailing to make it more probable that a return would be received from each county. It was believed that each county would be a more or less homogeneous unit and that a return from each county would present a picture that would be a fairly accurate representation of the state. It was hoped, but with less expectation of fulfillment, that a return would be received from one of the largest and one of the smallest districts within each county. If there were any differences within the county, returns from both the large and small districts would give some indication of the range of difference.

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[1] J. P. Guilford, Fundamental Statistics in Psychology and Education, (3rd ed.; New York: McGraw-Hill Book Company, Inc., 1956), p. 156.

Some time remained for follow-up questionnaires after the completion of the first mailing. Where questionnaires had been sent to elementary schools, and no reply had been received, follow-up questionnaires were sent to high schools. Time permitted sending follow-up questionnaires to only the eastern half of the state.

Preparation of the Questionnaire

The first question to be answered pertained to the qualifications of the eighth-grade teachers of Texas. The teachers were asked to list the number of courses they had taken in each of several disciplines. These subject matter areas were astronomy, geology, meteorology, mineralogy, oceanography, paleontology, agriculture, biology, chemistry, engineering, forestry, mathematics, and physics. The teachers were also asked to indicate how many earth science courses they had taken in order to provide a listing place for general earth science courses. Also requested was an indication of what degrees the teacher had earned, and the number of earth science courses they expected to teach each day.

Because teacher rating scales are difficult to construct, and even then do not always fulfill the purpose for which they were designed,[1] teacher preparation was judged solely upon the number of courses the teacher had taken in specified disciplines. These disciplines were the subdivisions of earth science, plus those scientific fields closely related to earth science.

The second question related to the scientific equipment available to the teacher. In order to determine what equipment the schools would need, it was first necessary to obtain the three state adopted textbooks. Each one was carefully examined and a list was prepared of all of the scientific equipment called for by each book. These three lists were combined into a single equipment list which then became part of the questionnaire. To make the completion of the questionnaire as easy as possible, it was requested that the principal of the school to which it was sent, check those items of equipment which he had, with no reference to the quantity available. Questions relating to the purchase of equipment and the amount of money budgeted would give clues to the amount of equipment available.

It was also asked when earth science was first taught at that school.

The questionnaire was tested at a conference relating to the latest developments in palynology held on the campus of East Texas State University on Saturday, February 20, 1965. The teachers who attended this conference were asked to complete a sample copy of the questionnaire and to tell what difficulties were encountered in completing it. They were asked to also make comments concerning both its contents and directions. From the responses elicited, it appeared that the questionnaire would obtain the information desired.

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[1] Philip G. Johnson, "Evaluating Science Teachers," _The Science Teacher_, (XXX, November, 1963), pp. 11-16.

Treatment of the Data

As the questionnaires were returned, the information contained on them was coded and punched into electronic computor cards.

The information concerning the teachers was tabulated according to the number of courses the teacher had in each of the thirteen disciplines of earth science or related science. From these data the subject matter areas in which the teachers were best prepared was determined, the amount of preparation which most teachers had in these particular disciplines, and whether or not this preparation met the standards suggested by the educators and scientists of the Earth Science Curriculum Project, and how many teachers met these standards. In the main, treatment consisted almost entirely of counting courses and determining the percentage, and modal number of the courses taken.

For the school to be adequately equipped to teach earth science, it needed at least one item of every one of the pieces of equipment listed on the equipment check list of the questionnaire. All that was necessary for this part of the questionnaire was to count the number of items of each type and to calculate the percentage of representation out of the total number of questionnaires returned.

To determine the number of schools teaching earth science was also only a matter of counting.

Two trips to the Texas Education Agency in Austin, Texas, were necessary in order to learn the locations of the eighth-grades of Texas. This information was needed in order to determine the effectiveness of the sampling method used. During July and August, 1965, each school in the *Public School Directory* was located in the accreditation files. The grades housed in that school were listed opposite its name in the directory. This produced a list of schools which housed the eighth-grades.

CHAPTER IV

FINDINGS AND RESULTS

READABILITY DETERMINATIONS

The evaluation of the textbooks that follows is based solely upon their reading level as determined by means of the Dale-Chall formula. While other factors affect the suitability of textbooks for a particular grade level,[1,2] and some are mentioned, only readability was investigated in this study.

The reading level of Basic Earth Science, one of the state adopted textbooks, ranges from a fifth-sixth-grade to a thirteenth-fifteenth-grade reading level. Its average reading level is at the ninth-tenth-grade level.

The reading level of Earth Science: The World We Live In, also an adopted textbook, ranges from a fifth-sixth-grade to a college-grade reading level. Its average reading level is at the ninth-tenth-grade level.

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[1] Bernard Berelson, Content Analysis in Communication Research (Glencoe, Illinois: The Free Press, 1952), pp. 63-65.

[2] John Addison Clement, Manual for Analyzing and Selecting Textbooks (Champaign, Illinois: The Gerrard Press, 1942).

The reading level of Modern Earth Science, also adopted, ranges from a fifth-sixth-grade to a college-grade reading level. Its average reading level is at the eleventh-twelfth-grade level.

The reading level of Exploring Earth Science ranges from a fifth-sixth-grade to a thirteenth-fifteenth-grade reading level. Its average reading level is at the ninth-tenth-grade level.

The reading level of Modern Science, an adopted book, ranges from a seventh-eighth-grade to a thirteenth-fifteenth-grade reading level. Its average reading level is at the ninth-tenth-grade level.

The reading level of Science is Understanding, also adopted, ranges from a fifth-sixth-grade to a eleventh-twelfth-grade reading level. Its average reading level is at the seventh-eighth-grade level.

The reading level of The Earth Sciences ranges from a ninth-tenth-grade to a college-grade reading level. Its average reading level is at the thirteenth-fifteenth-grade level.

These results are illustrated in Table 6 and 7 and in Figures 5 through 12. Table 6 shows both the extremes and average readability scores and illustrates the wide range of reading difficulty which exists in each book examined. Table 7 shows both the extremes and average sentence lengths and presents the wide variation that exists in the lengths of the sentences of these seven books.

Figures 5 through 12 show the variation in reading difficulty for each chapter analyzed in the seven textbooks studied. Also included is the Earth Science Curriculum Project's determination of the variability of reading difficulty, from chapter to chapter, of the first edition of Investigating the Earth.

These graphs show that there appears to be no orderly increase in reading difficulty from the beginning to the end of the book to allow for growth in reading skill. Basic Earth Science comes closest to showing this pattern, while Modern Science almost shows the reverse of this pattern. On the whole, all graphs show a very erratic pattern of reading difficulty, with Exploring Earth Science showing perhaps the least amount of variation. The graphs would indicate that there is a possibility that some authors and publishers are now trying to control the range of reading difficulty in the textbooks they are producing.

TABLE 6

THE EXTREMES AND AVERAGE READABILITY SCORES OF THE SEVEN TEXTBOOKS ANALYZED

Textbook Tile	Number of Sample Pages	Lowest Raw Score	Grade Level	Highest Raw Score	Grade Level	Range of Raw Scores	Average Raw Score	Average Grade Level
Basic Earth Science*	42	5.02	5 - 6	9.76	13-15	4.74	7.43	9 - 10
Earth Science: The World We Live In*	56	5.43	5 - 6	10.53	16+	5.10	7.82	9 - 10
Modern Earth Science*	59	5.79	5 - 6	11.31	16+	5.52	8.17	11 - 12
Exploring Earth Science	41	5.44	5 - 6	9.93	13-15	4.49	7.10	9 - 10
Modern Science*	40	6.32	7 - 8	9.78	13-15	3.46	7.63	9 - 10
Science is Understanding*	46	5.06	5 - 6	8.64	11-12	3.59	6.75	7 - 8
The Earth Sciences	62	7.27	9 - 10	11.73	16+	4.46	9.00	13 - 15

*State adopted, eighth-grade science textbooks.

TABLE 7

THE EXTREMES AND AVERAGE SENTENCE LENGTHS OF THE SEVEN TEXTBOOKS EXAMINED

Textbook Title	Shortest Sentence in words	Readability of that Passage	Longest Sentence in words	Readability of that Passage	Average Sentence Length in words	Average Readability
Basic Earth Science*	11	7 - 8	33	11 - 12	17	9 - 10
Earth Science: The World We Live In*	12	11 - 12	28	9 - 10	18	9 - 10
Modern Earth Science*	12	13 - 15	35	13 - 15	19	11 - 12
Exploring Earth Science	7	7 - 8	18 18	9 - 10 11 - 12	12	9 - 10
Modern Science*	10	11 - 12	24	9 - 10	18	9 - 10
Science is Understanding*	11	7 - 8	26	7 - 8	15	7 - 8
The Earth Sciences	16	9 - 10	50	16+	27	13 - 15

*State adopted, eighth-grade science textbooks.

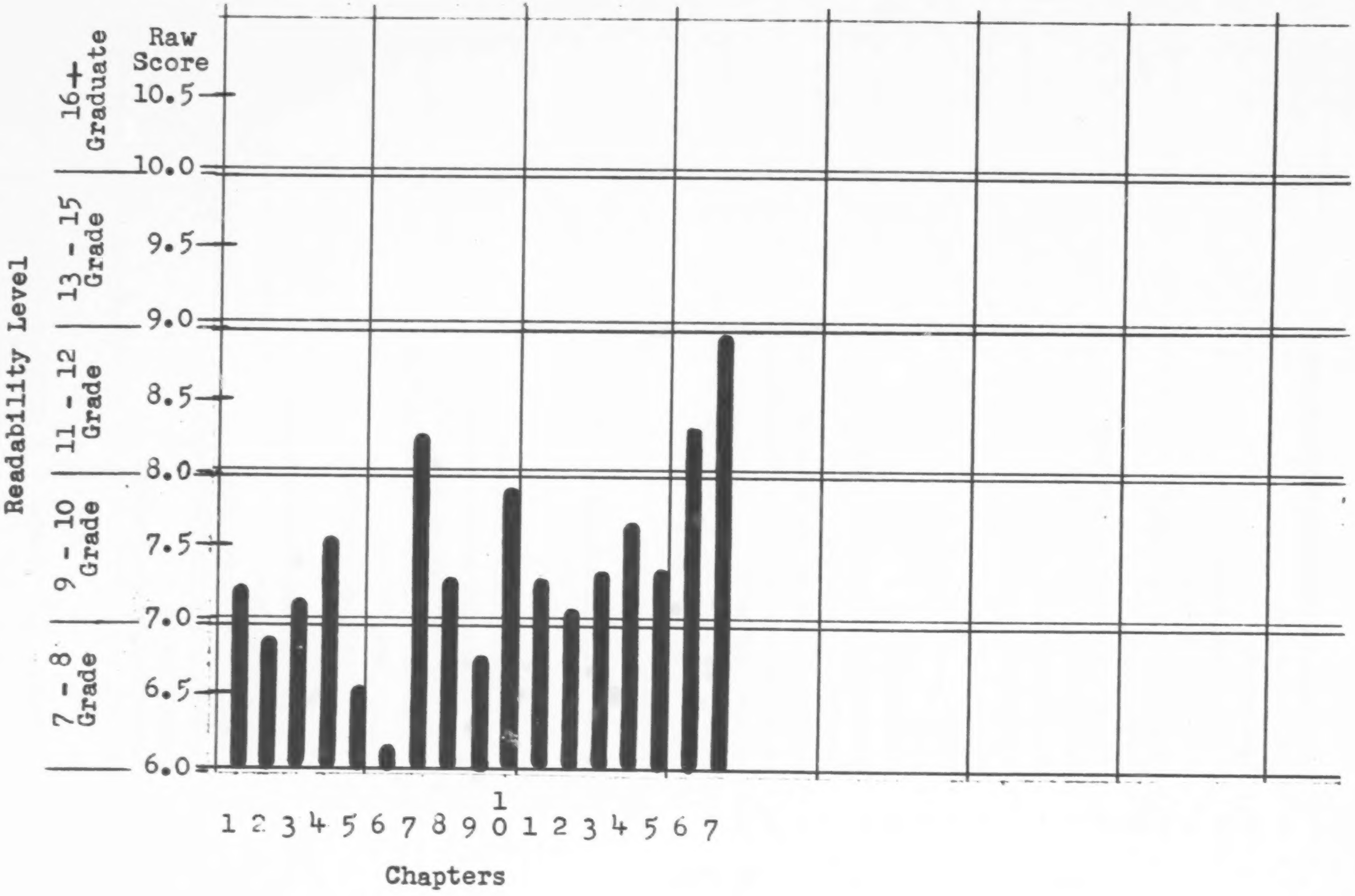

Figure 5.--Readability scores plotted by chapters
Basic Earth Science, MacCracken, Decker, Read, and Yarian (adopted textbook)

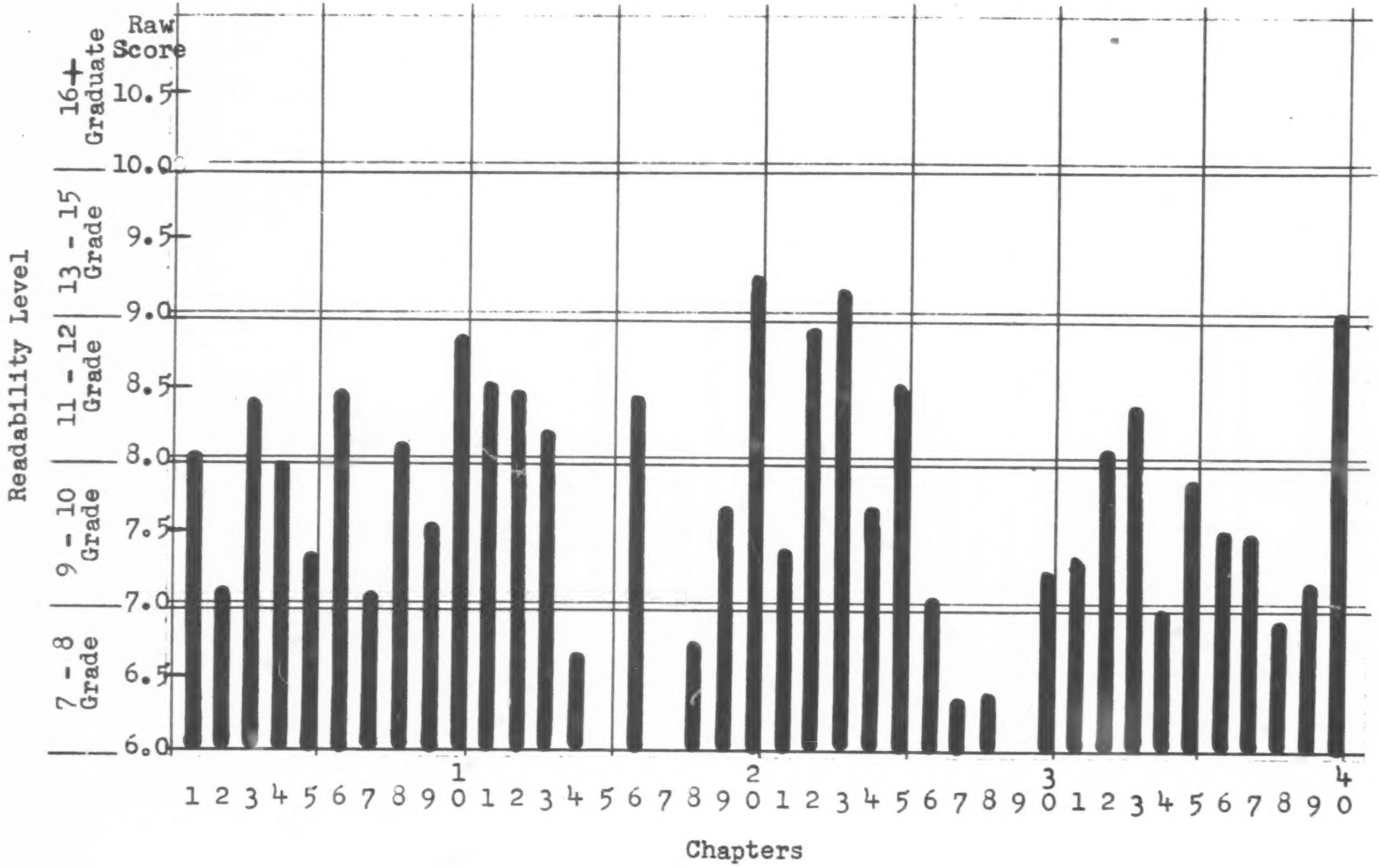

Figure 6.--Readability scores plotted by chapters
__Earth Science__: __The World We Live In__, Namowitz and Stone (adopted textbook)

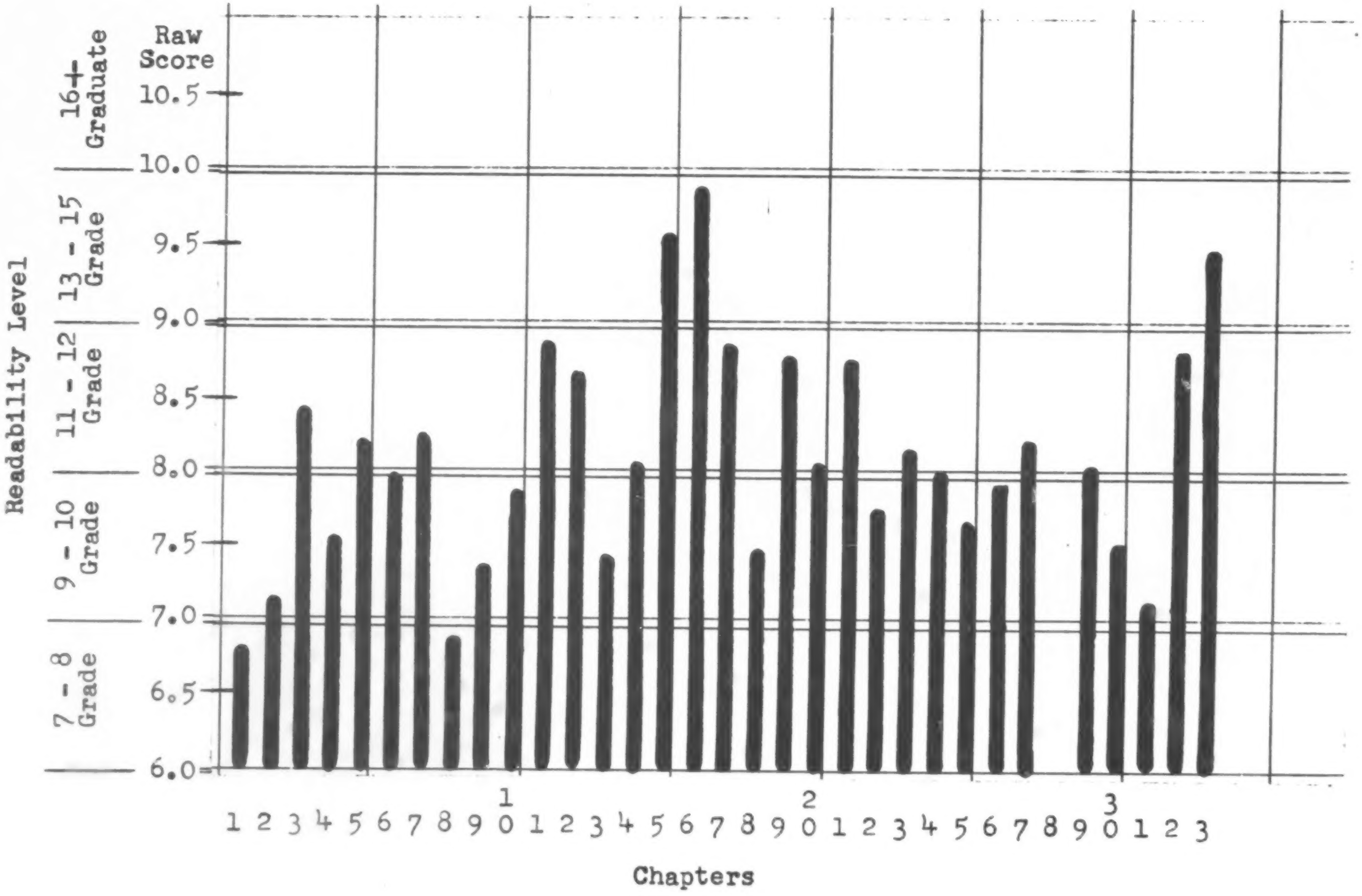

Figure 7.--Readability scores plotted by chapters
Modern Earth Science, Ramsey and Burckley (adopted textbook)

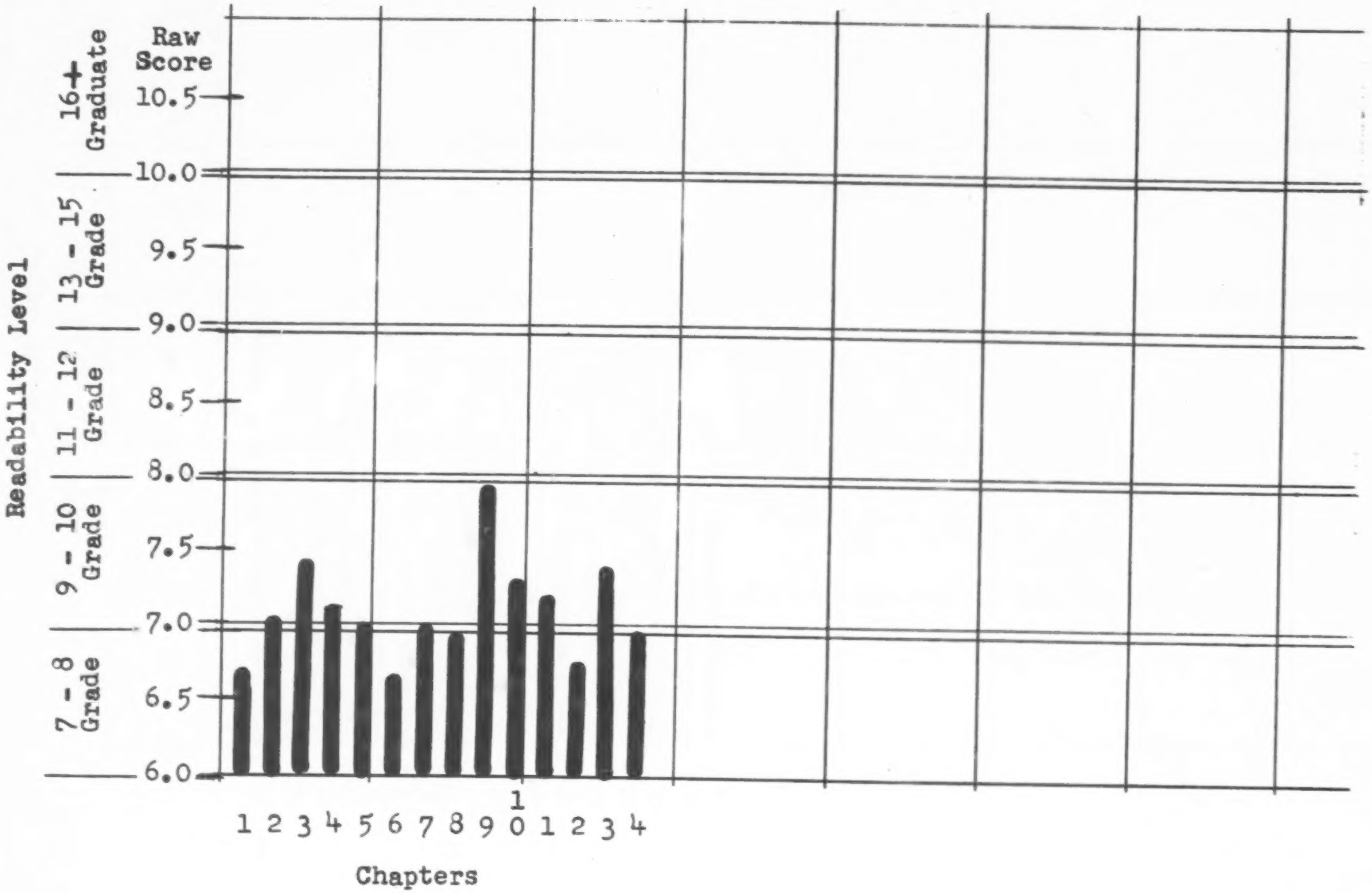

Figure 8.--Readability scores plotted by chapters
Exploring Earth Science, Thurber and Kilburn

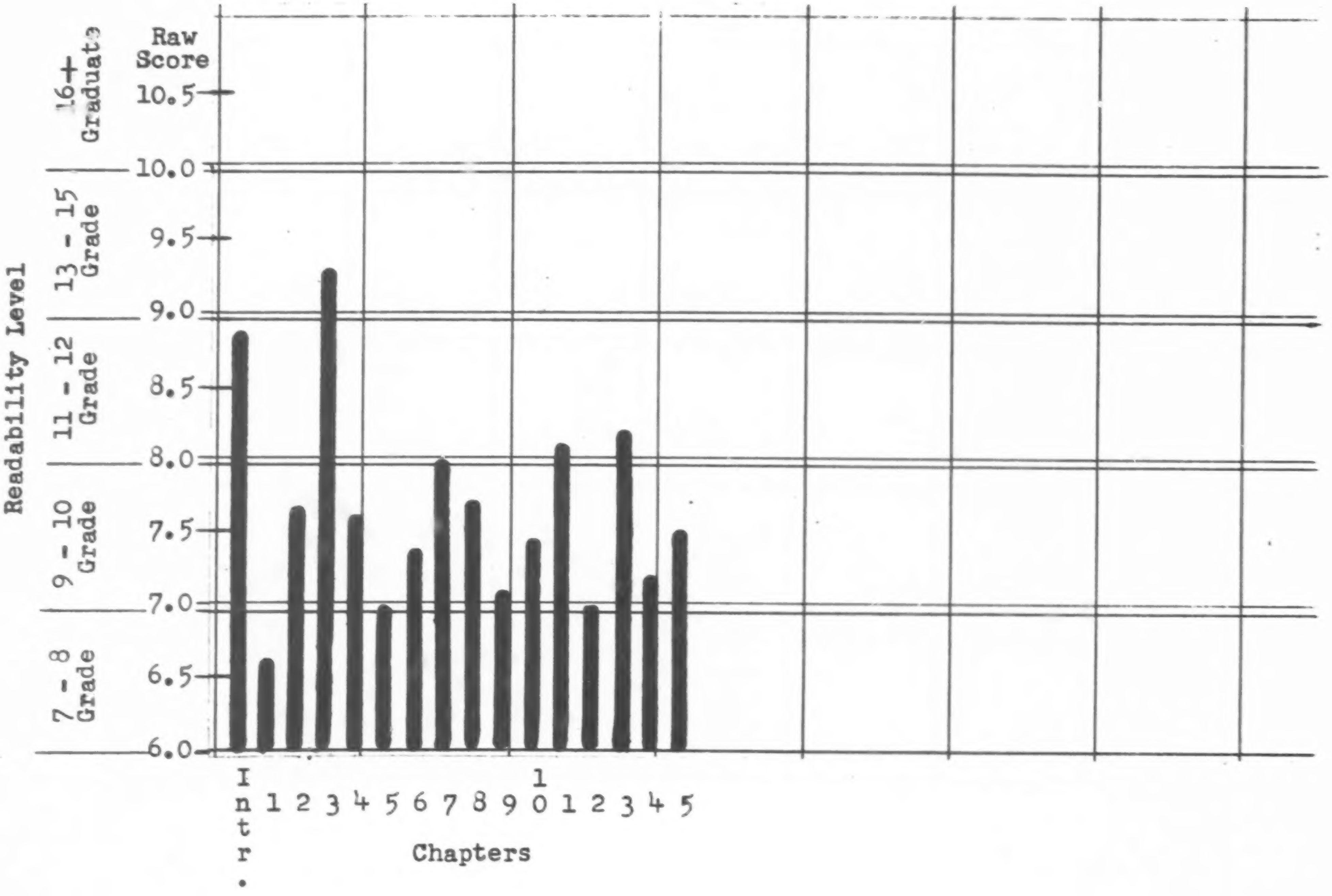

Figure 9.--Readability scores plotted by chapters
Modern Science, Blanc, Fischler, and Gardner (adopted textbook)

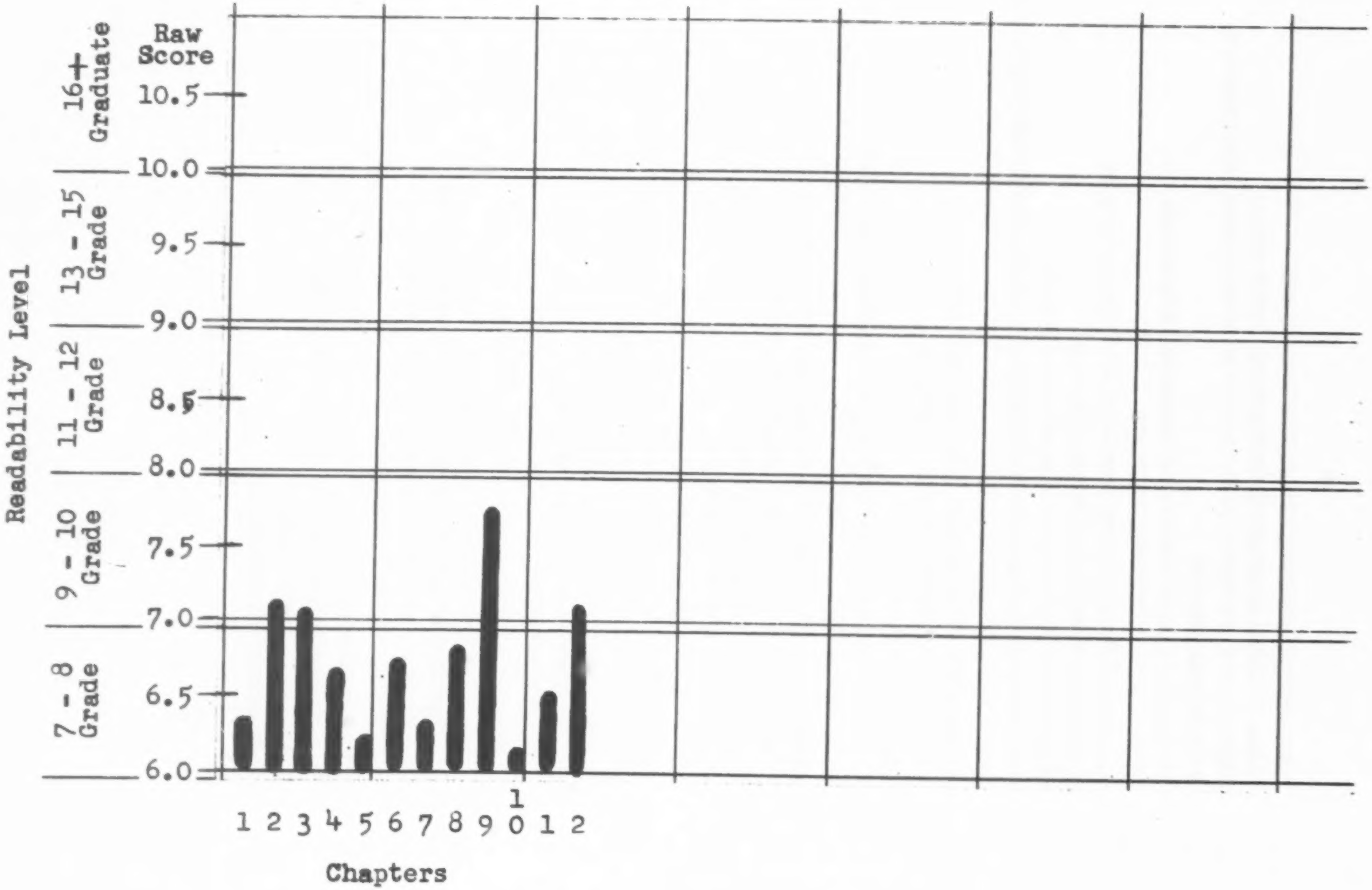

Figure 10.--Readability scores plotted by chapters
Science is Understanding, Beauchamp, Mayfield, and Hurd (adopted textbook)

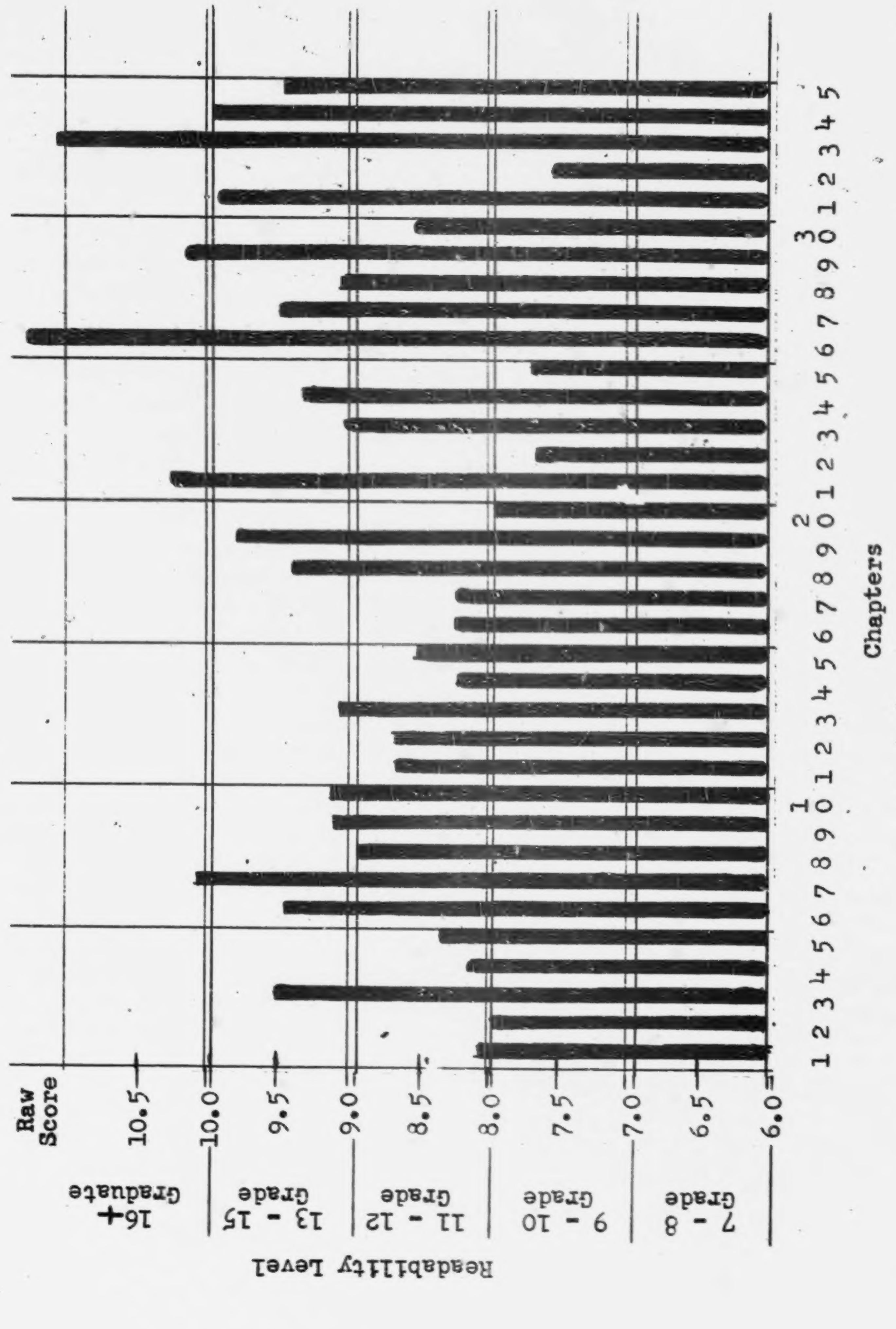

Figure 11.--Readability scores plotted by chapters
The *Earth* *Sciences*, Strahler

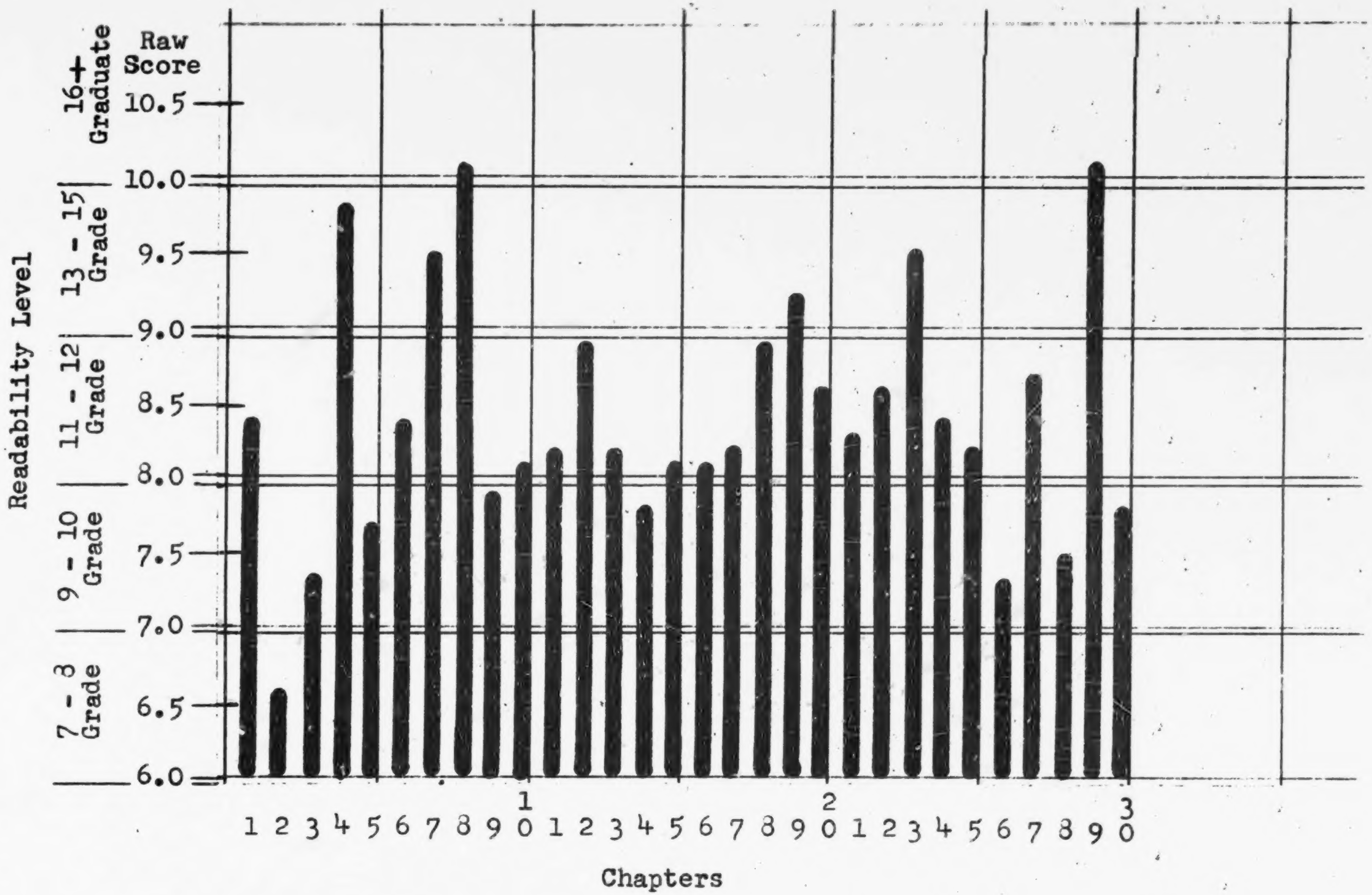

Figure 12.--Readability scores plotted by chapters Investigating the Earth, Earth Science Curriculum Project. Determination made by project workers.

According to Mallinson,[1] textbooks suitable for the eighth-grade should have a reading level of the fifth-sixth-grade. It would, therefore, appear that the two adopted textbooks most nearly suited for the eighth-grade students, Basic Earth Science and Earth Science: The World We Live In, would be difficult for all but the better students, but would have passages that would be difficult for even the superior students. The same thing would be true for Exploring Earth Science. Modern Earth Science would have passages that could be read and understood by all but the poorest students, but in general much of it would difficult for even the superior students. Modern Science has much less variation in reading level, but with its easiest passages written at a seventh-eighth-grade reading level, it is quite likely that this book would be difficult for most of the lower half of the class, and parts would be difficult for even the superior students. Science is Understanding also has less variation in reading level than do the earth science textbooks. Its easiest passages could be understood by all but the poorest readers, but its most difficult passages are likely to be understood only by superior students. The Earth Sciences is a college level textbook and its very high reading level would tax all but the most highly motivated, superior students.

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[1] George G. Mallinson, "Some Problems of Vocabulary and Reading Difficulty in Teaching Junior High School Science," School Science and Mathematics, (LII, April, 1952), p. 273.

Modern Science and Science is Understanding are adopted general science textbooks. Modern Science has no earth science material, at least none which could be isolated and identified as purely earth science material. It contains demonstrations and experiments, and has a glossary. However, about 2/3 of its content is devoted to the study of physics and about 1/3 to biology.

Science is Understanding does include earth science material, however, it is only one subdivision of this subject. Thirty-seven pages are devoted to meteorology. The other principle topics are physics, the human body, and physiological psychology. This book also contains demonstrations and experiments. This textbook would be classified by this author as a book of technology rather than one of science. It seems to be largely concerned with the things that the student would see in his daily life, and how these things work.

Based upon readability alone, Basic Earth Science and Exploring Earth Science appear to be the most suitable of the earth science textbooks, even though they would be difficult books for even the better students to use. Science is Understanding appears to be the better general science textbook for the same reasons that Basic Earth Science and Exploring Earth Science were selected. In these three books the highest reading level score is lower than that of the other books and there is less range in variation of reading level throughout the books. The narrower range in reading level tends to make the books easier to read.

This is not the whole story. All of these books contain too many words which are unfamiliar to the average eighth-grade student. In addition, the sentences are much too long to be easily understood.

Because readability determinations had already been made by other workers, this author did not make any new determinations of reading difficulty of the first and second editions of Investigating the Earth. A determination of the reading level was made of the first edition by the staff of the Earth Sciences Curriculum Project.[1] They found that the readability level ranged from seventh-eighth-grade to college-grade, with the average readability at the eleventh-twelfth-grade level. This was too high an average grade for a book intended for use in the ninth-grade and contained too high an amount of reading level variation.

An effort was made in writing the second edition to decrease the reading difficulty and the amount of variation as well. An unpublished readability determination made by McMurdie indicated that the writers succeeded in reducing the average reading level of the second edition of Investigating the Earth to a ninth-tenth-grade reading level.[1]

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[1] Shrum, personal communication.

TEACHER PREPARATION AND EQUIPMENT STATUS OF TEXAS SCHOOLS

Teacher Preparation

Texas schools have been organized for many years on a segregated basis. Both white and Negro schools were sampled; however, only four Negro schools replied to the questionnaire. As a consequence, the data reported herein relates almost completely to the situation as it existed in the white schools.

Based upon the study of the accreditation files, it was found that during the 1964-65 school year there were 1466 white eighth-grades in Texas. Of these 371 were housed in high schools, 566 in junior high schools, and 529 in elementary schools, plus 86 about which some question regarding their location and existence was noted in the accreditation files.

There were also 446 Negro eighth-grades in Texas. Of these, 200 were housed in high schools, 34 in junior high schools, and 212 in elementary schools, plus 21 about which some question regarding their location and existence was noted in the accreditation files.

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[1] Dennis S. McMurdie, University of Utah, personal communication from John W. Shrum.

To these 1912 eighth-grades, 1025 questionnaires were mailed. Of these 278 questionnaires were completed, in whole or in part, and returned. Of the 1025 questionnaires mailed out, in 704 cases they went to a school housing an eighth-grade, and in 321 cases to schools with no eighth-grade. Of the 704 going to the correct school, 229 replied; of the 321 going to the wrong school, 49 replied.

There were 253 counties with schools which housed eighth-grades, but one was overlooked and no questionnaires were sent to its schools. Replies were received from 172 counties, and these counties contained about 90 per cent of the school population and about 90 per cent of the assessed evaluation of the state, based upon the figures given in the Public School Directory. Figure 13 shows the counties from which returns were received. It also shows the county where schools only go up to the sixth-grade.

A total of 491 teachers reported the number of science courses they had taken. Of these 491 teachers, 288 reported that they had earned a bachelor's degree, and 149 reported that they had earned a master's degree.

These 491 teachers were first studied as a group. This group of teachers was examined in relation to the thirteen science and earth science areas listed on the questionnaire. As a group, more teachers reported not having taken any courses, in this selection of courses, than reported

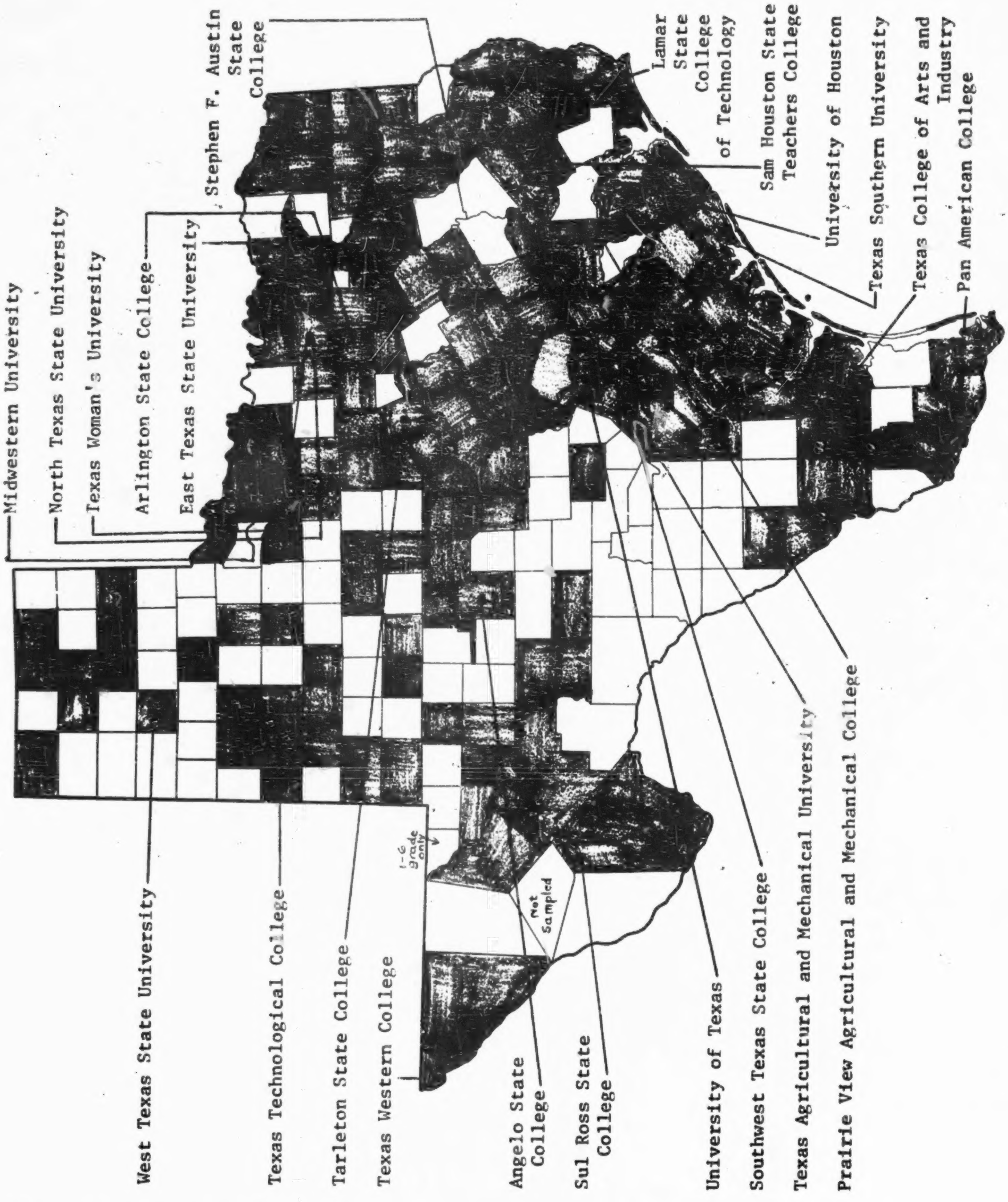
Midwestern University
North Texas State University
Texas Woman's University
Arlington State College
East Texas State University
Stephen F. Austin State College
Lamar State College of Technology
Sam Houston State Teachers College
University of Houston
Texas Southern University
Texas College of Arts and Industry
Pan American College
West Texas State University
Texas Technological College
Tarleton State College
Texas Western College
Angelo State College
Sul Ross State College
University of Texas
Southwest Texas State College
Texas Agricultural and Mechanical University
Prairie View Agricultural and Mechanical College
1-6 grade only
Not Sampled

Figure 13.--Map showing the Colleges and Universities supported by the State of Texas and the counties from which completed questionnaires were returned having taken them. Thus, in every case the mode would be no courses taken. These results are illustrated in Table 8 and Figures 14 through 19. The figures give a very clear picture of this lack of preparation.

Examination of Table 8 will also show that 86 per cent of the teachers reporting had no courses in astronomy, and 98 per cent had two or less courses. In geology, 64 per cent of the teachers reported no courses, and 91 per cent two or less courses. In meteorology, 87 per cent reported no courses, and 99 per cent two or less. In mineralogy, 89 per cent reported no courses, and 98 per cent two or less. In oceanography, 94 per cent reported no courses, and 99 per cent two courses or less. In paleontology, 90 per cent reported no courses, and 98 per cent two or less. In earth science, 58 per cent reported that they had taken no courses, and 70 per cent reported that they had taken two or less courses.

Based upon these findings, as a group, the teachers reporting were not prepared to teach earth science courses in the eighth-grades of Texas.

TABLE 8

DISTRIBUTION OF TEACHERS BY THE NUMBER OF COURSES THEY HAVE TAKEN IN SPECIFIED DISCIPLINES

Name of the Course	Number of Courses with the Number of Teachers who have taken that number of courses listed below																					Mode	Number of People in the Number of Classes most Frequently Taken	Percentage with No Courses	Percentage with 2 or less Courses
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21 or more			
Astronomy	424	52	7	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52 - 1	86	98
Geology	323	74	48	9	7	4	5	1	2	0	3	1	1	1	3	2	1	0	0	0	2	1	0	74 - 1	64	91
Meteorology	428	52	4	4	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52 - 1	87	99
Mineralogy	437	34	11	5	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34 - 1	89	98
Oceanography	463	23	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23 - 1	94	99
Paleontology	444	27	10	6	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27 - 1	90	98
Earth Science	286	27	29	14	23	7	7	8	10	4	6	3	9	3	3	3	2	0	0	1	6	40	0	29 - 1	58	70
Agriculture	374	23	5	8	5	2	1	0	6	1	4	0	0	6	1	7	2	0	7	0	12	27	0	23 - 1	76	82
Biology	97	34	60	29	46	24	46	15	29	10	19	7	12	4	12	3	1	2	10	5	4	22	0	60 - 2	20	39
Chemistry	155	41	95	48	50	17	25	9	17	4	5	5	8	2	0	0	1	0	2	2	1	4	0	95 - 2	32	59
Engineering	429	26	22	7	4	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	26 - 1	87	97
Home Economics	450	12	3	3	0	1	1	0	1	0	1	0	3	1	2	0	0	0	3	0	1	9	0	12 - 1	92	95
Forestry	473	13	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	13 - 1	96	99
Mathematics	162	60	113	36	31	23	23	9	8	10	5	2	4	0	2	5	0	1	1	0	1	2	0	113 - 2	33	68
Physics	283	68	82	20	13	3	5	1	8	1	2	0	2	1	0	0	0	0	1	0	0	1	0	82 - 2	58	70
Number of Earth Science Classes the Teacher expects to teach a day	170	77	65	56	36	69	18																			

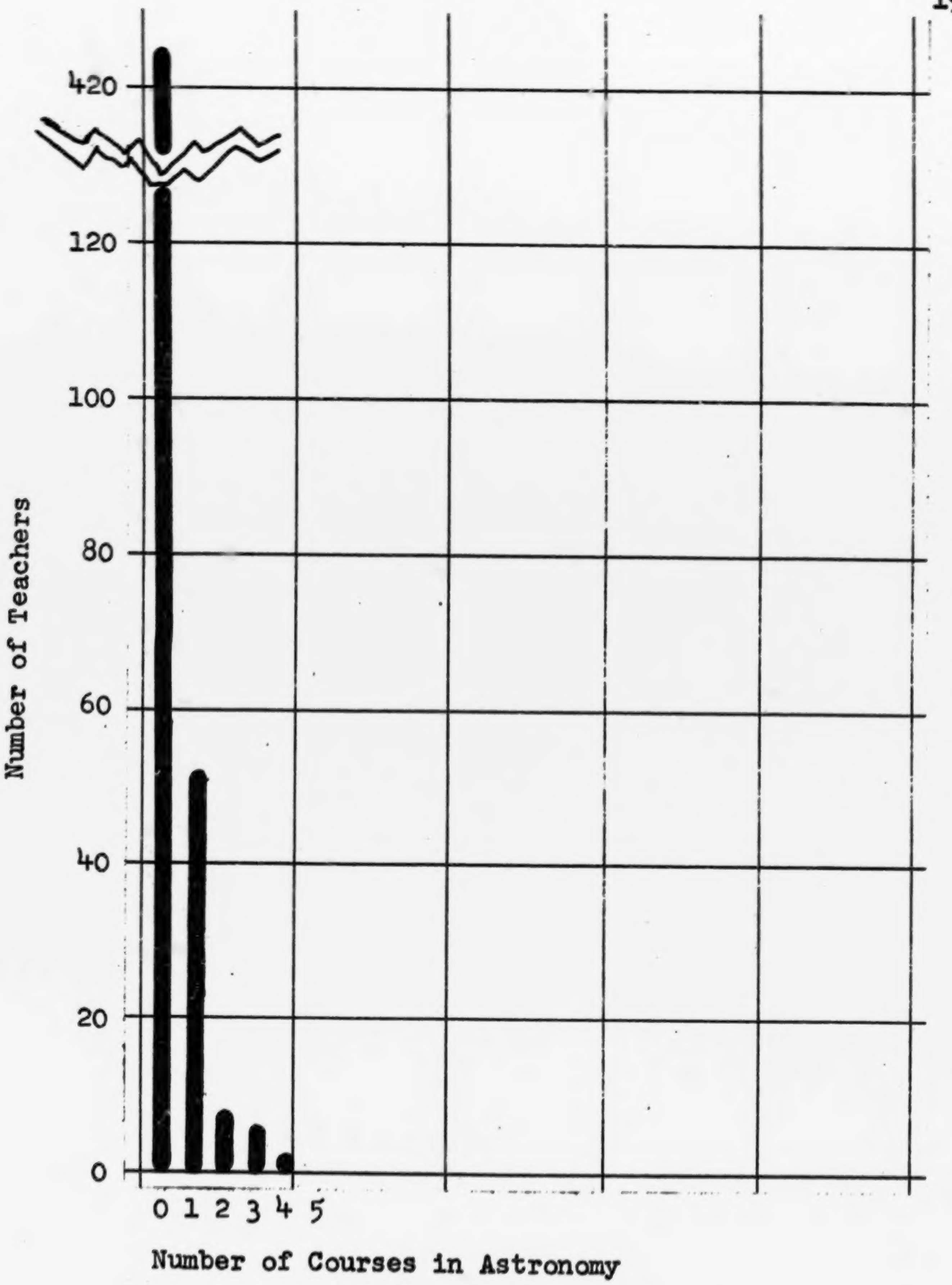

Figure 14.--The number of teachers who have taken courses in astronomy plotted against the number of astronomy courses taken

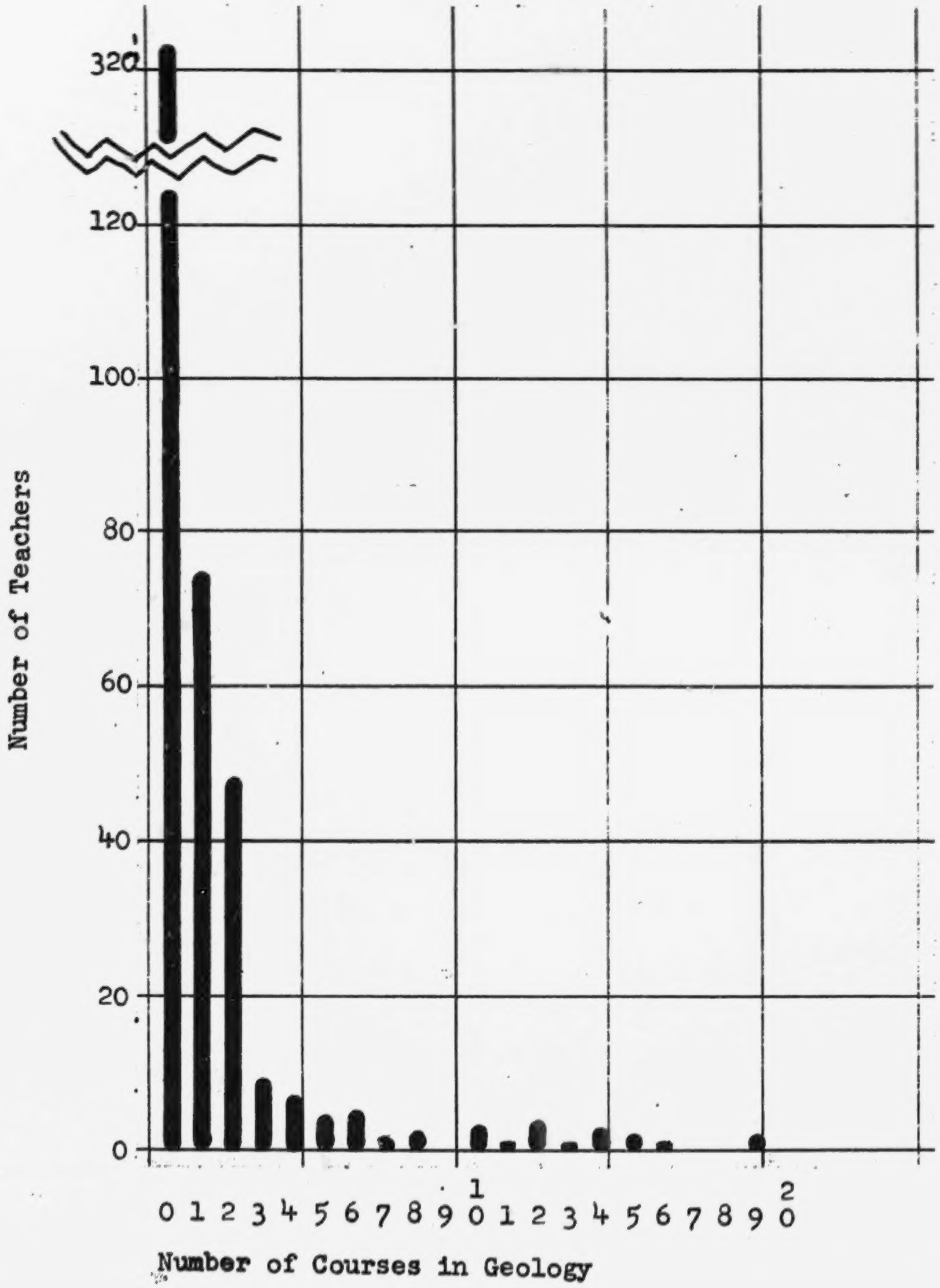

Figure 15.--The number of teachers who have taken courses in geology plotted against the number of geology courses taken

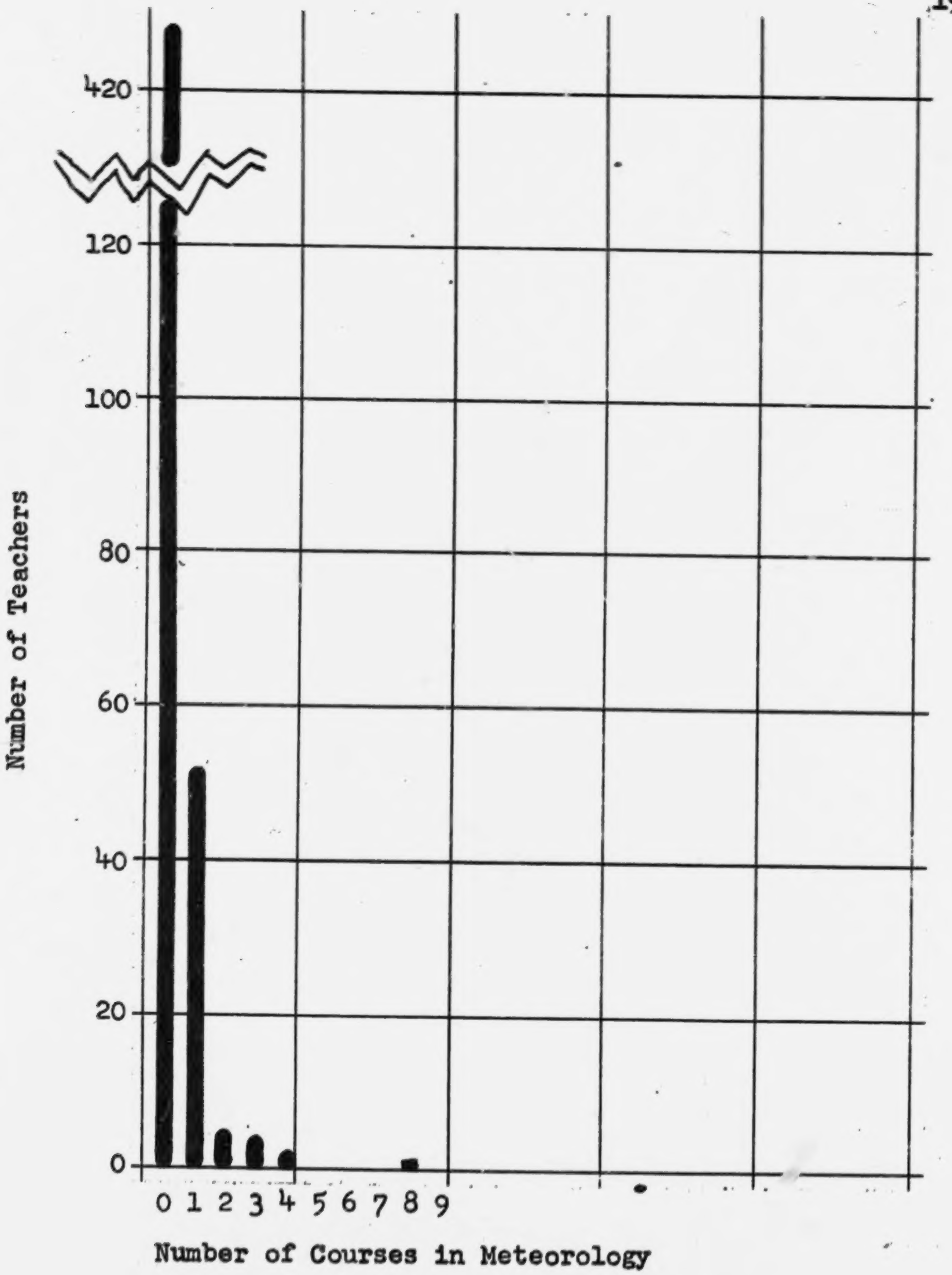

Figure 16.--The number of teachers who have taken courses in meteorology plotted against the number of meteorology courses taken

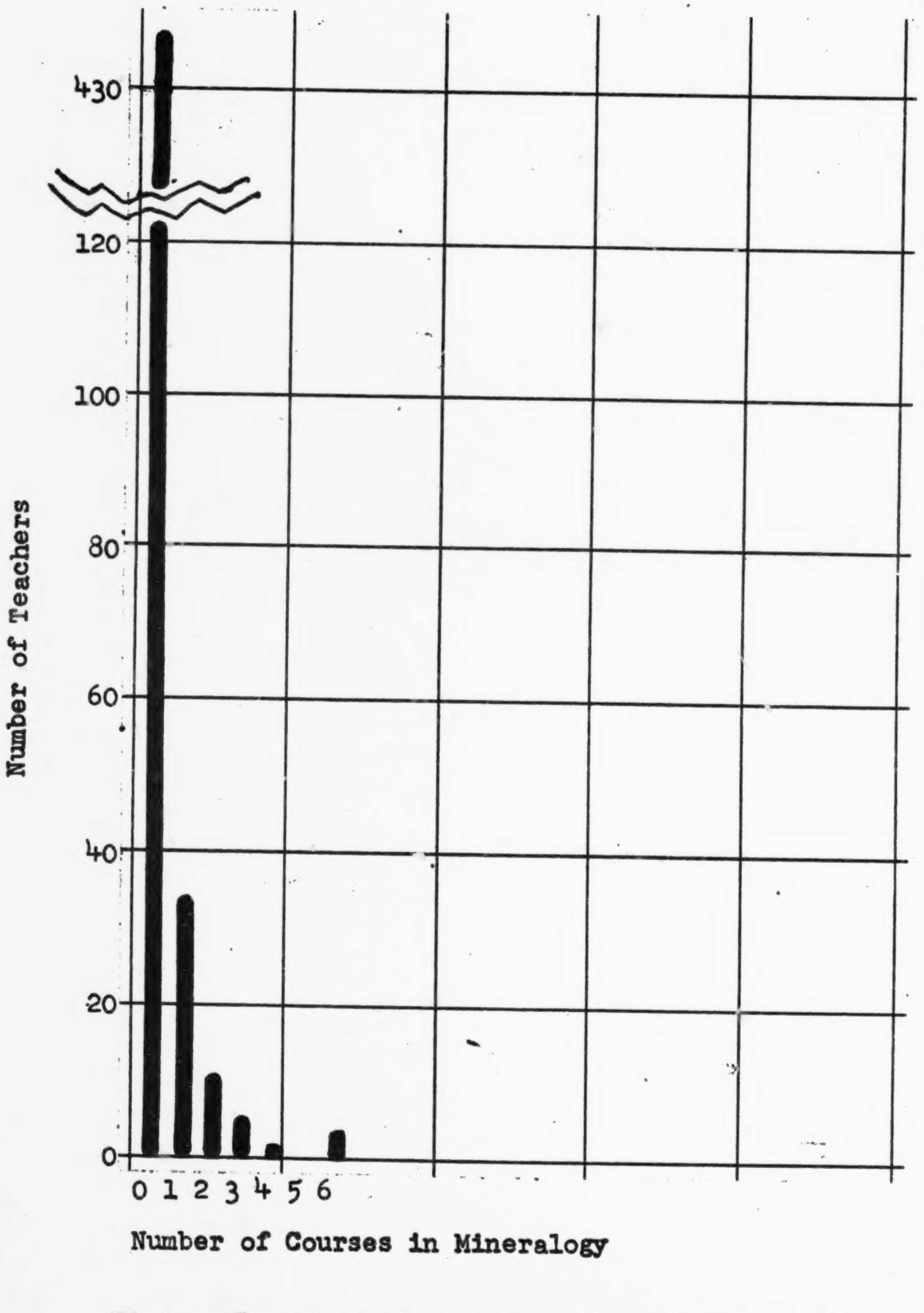

Figure 17.--The number of teachers who have taken courses in mineralogy plotted against the number of mineralogy courses taken

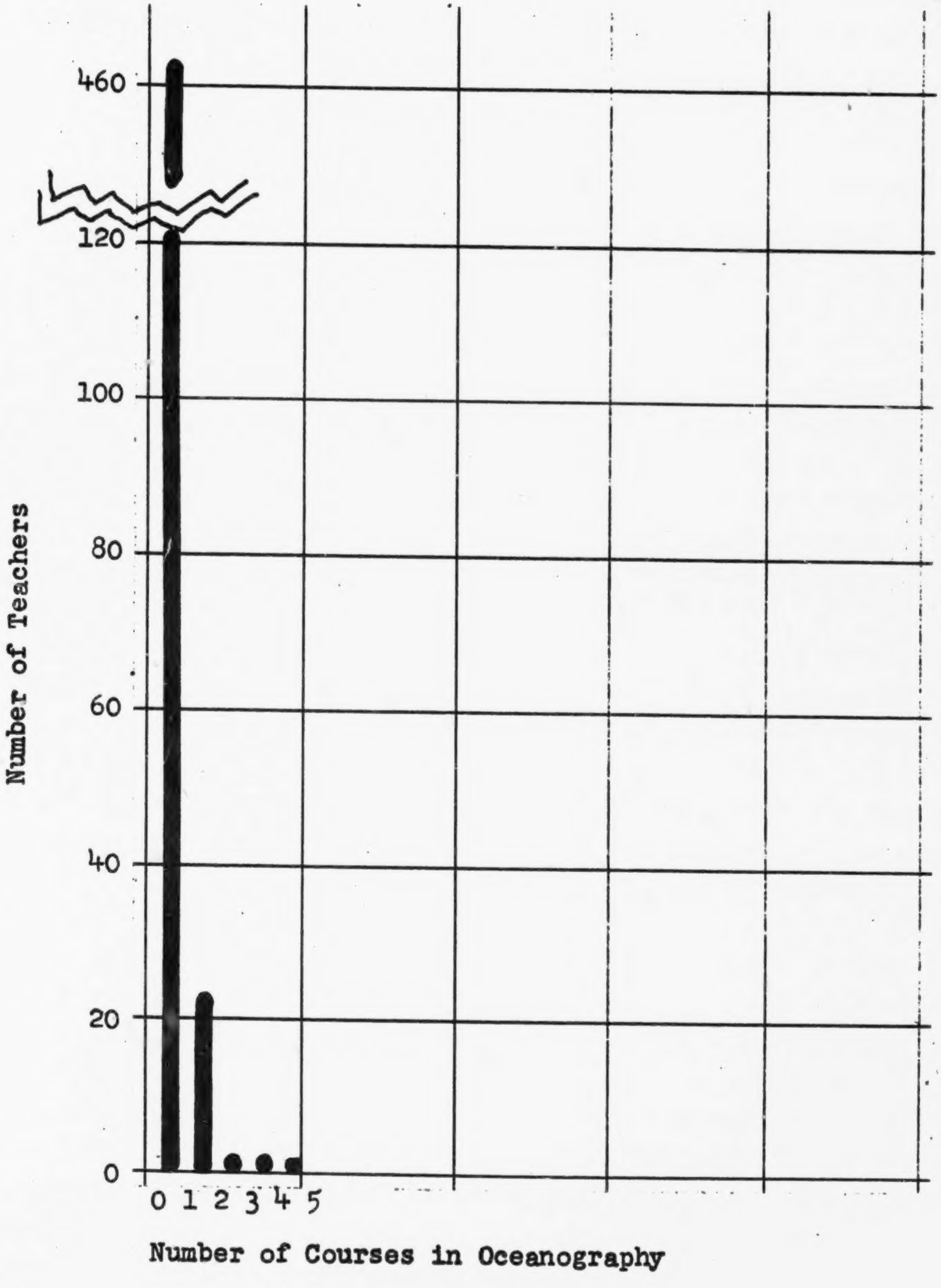

Figure 18.--The number of teachers who have taken courses in oceanography plotted against the number of oceanography courses taken

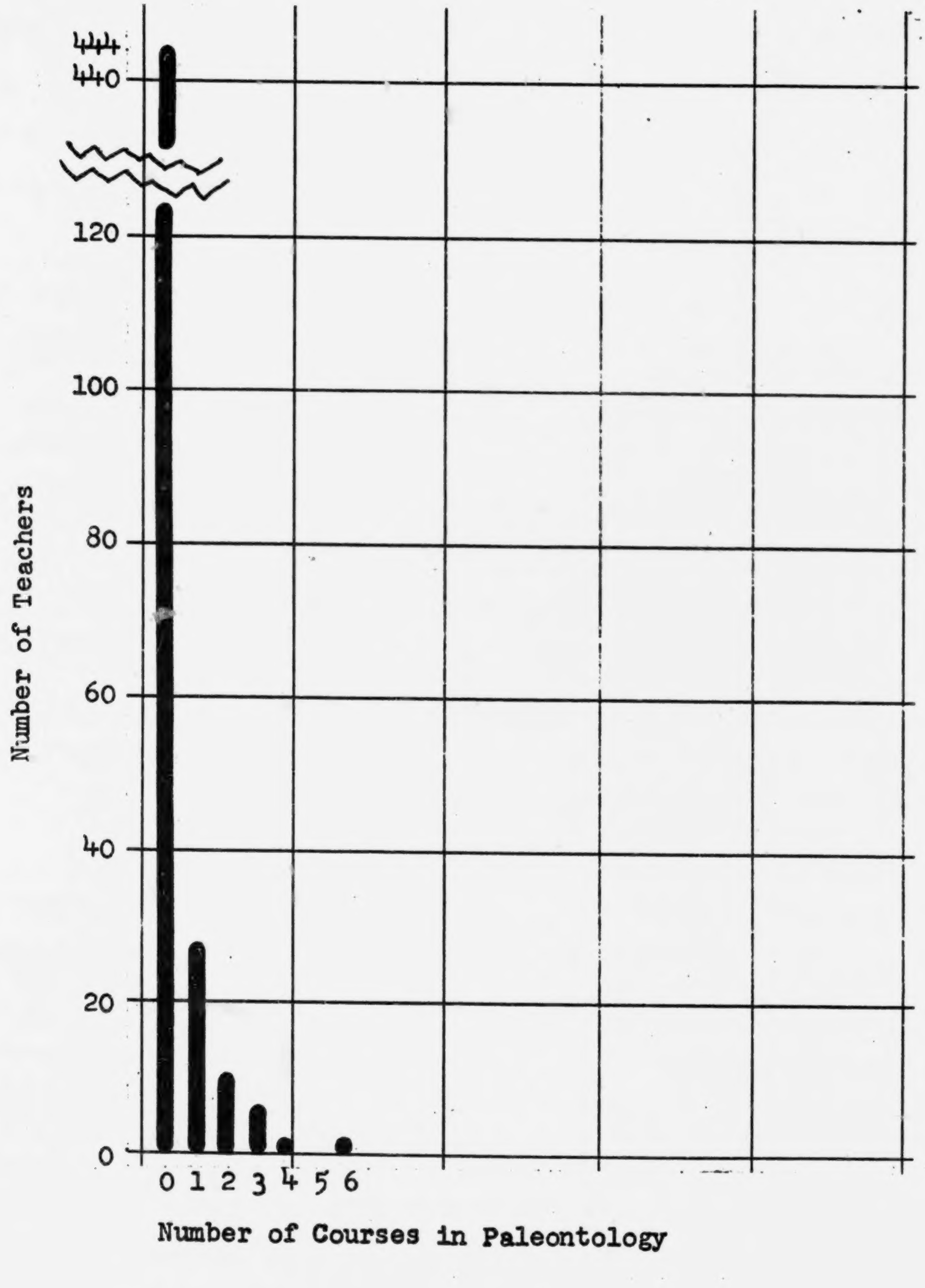

Figure 19.--The number of teachers who have taken courses in paleontology plotted against the number of paleontology courses taken

In the spring of 1965 a questionnaire prepared by the ESCP staff was sent to 8,463 teachers listed as earth science teachers in the U. S. Registry of Junior and Senior High School Science and Mathematics Personnel. Replies were received from 3,224 (38 per cent response) teachers. Of these 2,480 were currently teaching earth science. The earth science teachers reported the following state of academic preparation: 53 per cent had no astronomy and 94 per cent had six credit hours or less in this subject; 22 per cent had no geology and 58 per cent six credit hours or less; 62 per cent had no meteorology and 96 per cent six credit hours or less; 89 per cent had no oceanography and 99 per cent six credit hours or less; and 50 per cent had no physical geography and 85 per cent had six credit hours or less. These results, obtained from a national study, are quite similar to those obtained for the State of Texas.[1]

Examination of individual questionnaires revealed that twenty-two teachers had taken ten or more earth science courses. These courses were well distributed among the various earth science disciplines. These twenty-two teachers had taken ten or more courses in other areas of science and mathematics. These related scientific fields were biology, chemistry, and physics. Three additional teachers had also taken ten or more earth science courses, but they had taken less than ten courses in related science and mathematics areas.

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[1] James H. Shea, "Highlights of 1965 ESCP Survey of Earth Science Teachers," Journal of Geological Education, (XIV, February, 1966), p. 9.

If each course carried the normal three credit hour value, of the 491 teachers reporting, only twenty-two met the standards suggested for teachers of earth science by the Earth Science Curriculum Project. These standards, which have been presented in full in Figure 1, suggest thirty hours as a minimum of earth science courses plus an additional thirty hours divided among biology, chemistry, physics, and mathematics. This would indicate that only four and one-half per cent of the teachers, who reported, met the qualifications suggested by the Earth Science Curriculum Project for teachers of earth science.

The 491 teachers who responded to the questionnaire were faculty members of 276 schools. The teachers and principals of these 276 schools estimated that between 320 and 360 of these teachers would offer instruction in earth science to an estimated 1128 classes. These figures indicated that each teacher would average three earth science classes a day; however, seventy-five of these teachers reported that they were likely to teach only one earth science class each day. Eighteen teachers indicated that they expected to teach as many as six classes of earth science a day. This distribution is shown in Table 8.

In a study made during the 1964-65 academic year, Bennett sent questionnaires to 709 of the "approximately seven hundred seventy (770) designated junior high schools in the State of Texas."[1] He received completed questionnaires from about 34 per cent of the schools to which he sent questionnaires.[2]

Equipment and its Availability to the Teachers

A list of equipment that was necessary in order to perform the demonstrations and experiments given in the three state adopted earth science textbooks was prepared. This list was made into a check list and sent to the principals of the schools that were being sampled. If the school had an item of equipment contained on the list, the principal indicated ownership by placing a check mark in the space following the article. If all of the items were checked, the school had all of the equipment called for by the three adopted earth science textbooks.

A total of 275 schools returned completed check lists.

This list has been reproduced as Tables 9 through 14. The equipment was subdivided in the tables according to the scientific discipline to which it appeared to be most closely related. These six subdivisions were Geology and Mineralogy, Paleontology, Astronomy and Meteorology, Biology, Chemistry, and Physics. The tables show that the schools were best equipped in the fields of Chemistry, Biology, and Physics. They were not as well equipped in the fields of Geology and Mineralogy, Astronomy and Meteorology, and Paleontology.

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[1] Lloyd M. Bennett, "Comparison of Current Science Teaching Practices in Texas Junior High Schools " *School Science and Mathematics*, (LXVI, February, 1966), p. 142.

[2] *Ibid*.

TABLE 9

SCHOOLS REPORTING OWNERSHIP OF GEOLOGY AND MINERALOGY EQUIPMENT

Item of Equipment	Number of Schools Reporting Ownership of this Equipment	Percentage of the 275 Schools Reporting Ownership of this Equipment
Charcoal Blocks	124	45.1
Geographic Maps	146	53.1
Topographic Maps	106	38.5
Mineral Collection	196	71.3
Sand	198	72.0
Sandstone	180	65.5
Shale	173	62.9
Limestone	203	73.8
Salt	201	73.1
Flint	170	61.8
Agate	141	51.3
Chalcedony	81	29.5
Quartz	182	66.2
Milky Quartz	163	59.3
Red Iron Ore	139	50.5
Yellow Iron Ore	87	31.6

TABLE 9--Continued

Item of Equipment	Number of Schools Reporting Ownership of this Equipment	Percentage of the 275 Schools Reporting Ownership of this Equipment
Bauxite	142	51.6
Gypsum	158	57.5
Sulphur	205	74.5
Marble	184	66.9
Talc	147	53.5
Mica	172	62.5
Microcline	82	29.8
Granite	179	65.1
Hornblende	104	37.8
Basalt	139	50.5
Obsidian	134	48.7
Asbestos	163	59.3
Fluorite	132	49.0
Hematite	135	49.1
Lodestone (Magnetite)	136	49.5
Pyrite	154	56.0
Copper Ore	136	49.5
Galena	124	45.1

TABLE 10

SCHOOLS REPORTING OWNERSHIP OF PALEONTOLOGY EQUIPMENT

Item of Equipment	Number of Schools Reporting Ownership of this Equipment	Percentage of the 275 Schools Reporting Ownership of this Equipment
Fossil Collection	126	45.8
Shell Collection	106	38.5
Trilobites	78	28.4
Brachiopods	60	21.8
Crinoids	61	21.8
Coral	116	42.2
Pelecypods	51	18.5
Oysters	75	27.3
Leaf Impressions	108	39.3
Fossil Wood	117	42.5
Models of Dinosaurs	37	13.5

TABLE 11

SCHOOLS REPORTING OWNERSHIP OF ASTRONOMY AND METEOROLOGY EQUIPMENT

Items of Equipment	Number of Schools Reporting Ownership of this Equipment	Pecentage of the 275 Schools Reporting Ownership of this Equipment
Binoculars	49	17.8
Electric Fan	138	50.2
Step Ladder	94	34.2
Sky Charts	123	44.7
Globe	211	76.7
Weather Maps	162	58.9
Barometer	192	69.8
Rain Gauge	128	46.5
Theromometer, Fahrenheit	228	82.9
Theromometer, Centigrade	206	74.9
Sling Psychrometer	63	22.9
Models of the Universe	85	30.9
Silver Iodide	118	42.9

TABLE 12

SCHOOLS REPORTING OWNERSHIP OF BIOLOGY EQUIPMENT

Item of Equipment	Number of Schools Reporting Ownership of this Equipment	Percentage of the 275 Schools Reporting Ownership of this Equipment
Microscope	219	79.6
Microscope Slides	216	78.5
Canada Balsam	50	18.2
Cover Glasses	206	74.9
Tongs	214	77.8

TABLE 13

SCHOOLS REPORTING OWNERSHIP OF CHEMISTRY EQUIPMENT

Item of Equipment	Number of Schools Reporting Ownership of this Equipment	Percentage of the 275 Schools Reporting Ownership of this Equipment
Bunsen Burners	221	80.4
Ring stands	226	82.2
Ring Stand Clamps	226	82.2
Glass Dishes	219	79.6
Glass Plates	198	72.0
Glass Bottles	224	81.5
Squeeze Bottles	110	40.0
Wide Mouth Jars	205	74.5
Glass Jars	211	76.7
Rubber Stoppers	229	83.3
Trays	179	65.1
Glass Tubing	225	81.8
Triangular Files	188	68.4
Rubber Tubing	223	81.1
Hose Clamps	205	74.5
Hot Plate	123	44.7

TABLE 13--Continued

Item of Equipment	Number of Schools Reporting Ownership of this Equipment	Percentage of the 275 Schools Reporting Ownership of this Equipment
Beakers, assorted sizes	227	82.5
Flasks, assorted sizes and kinds	207	65.3
Graduated Cylinders	208	75.6
Test Tubes, assorted sizes	213	77.5
Hydrochloric Acid	219	79.6
Copper Sulphate	188	68.4

TABLE 14

SCHOOLS REPORTING OWNERSHIP OF PHYSICS EQUIPMENT

Item of Equipment	Number of Schools Reporting Ownership of this Equipment	Percentage of the 275 Schools Reporting Ownership of this Equipment
Magnetic Compass	207	75.3
Bar Magnets	221	80.4
Horseshoe Magnets	199	72.4
Magnifying Glasses	220	80.0
Lenses	206	74.9
Triangular Prisms, Glass	210	76.4
Toy Gyroscope	112	40.7
Extension Cords	210	76.4
Dry Ice	82	29.8
Wooden Blocks	150	54.4
Hammer	176	64.0
Mailing Tubes	48	17.5
Rectangular Acquarium or Tank	157	57.1
Record Player or Turntable	146	53.1
Scale, Beam Balance	194	70.5
Weights for Beam Balance Scale	162	58.9

TABLE 14--Continued

Item of Equipment	Number of Schools Reporting Ownership of this Equipment	Percentage of the 275 Schools Reporting Ownership of this Equipment
Scale, Spring Balance	177	64.4
Pans, assorted sizes	151	54.9
Copper Wire	208	75.6
Iron Rods	170	61.8
Iron Wire	166	60.4
Iron Filings	211	76.7
Thermometer, Celsius	117	42.5
Atomic Models	67	24.4

In order to determine approximately how well equipped the schools were, the percentage of equipment available for use was calculated. It was found that the schools which reported had 74.0 per cent of the chemistry equipment called for by the textbooks; 65.8 of the biology equipment; 60.1 per cent of the physics equipment; 54.7 per cent of the geological and mineralogical equipment; 50.3 per cent of the astronomical and meteorological equipment; and 30.9 per cent of the equipment need for paleontology. From these figures it was estimated that only 49.2 per cent of the equipment closely related to one or more of the disciplines of earth science was on hand at the beginning of the 1965-66 school year.

Equipment is of no use to the teacher unless it is available when it is needed. Equipment can be stored in many places, and is frequently stored in more than one place. Some of the possible storage places are indicated in Table 15 with the teachers' opinion regarding its availability. Most teachers favor having the equipment stored in the room in which it will be used. The least favored place for storage was in a building different from the one in which it will be used. Very few schools, 46 of the 275 or 16 per cent, have a formal procedure which must be followed by the teacher in order to obtain equipment.

TABLE 15

TEACHERS REACTION TO THE PLACE OF STORAGE OF SCIENTIFIC EQUIPMENT USED BY THEM IN THE CLASSROOM OR LABORATORY

In the teachers' opinion the place of equipment storage which	Number of teachers reporting that they prefer equipment to be stored in...			
	the classroom of the teachers who will use it	a central place	a laboratory	a building different from the one in which it will be used
provides for maximum use	128	100	105	3
provides for adequate use	123	106	112	6
limits the use	17	19	16	5
discourages the use	6	9	8	3
Reported to be the place where the equipment is stored. Total	164	130	136	12

The fact that 276 schools report 442 places where equipment is stored, indicates that the equipment is stored in more than one place, in at least some of the schools reporting.

When equipment is to be purchased 220, or 80 per cent of the teachers, reported that they were consulted concerning the type and brand of equipment to be purchased. A total of 201, or 75 per cent of the teachers, reported they could also get the type and brand of equipment they desired.

The schools which reported specific budget items for scientific equipment numbered 132, or 48 per cent of the schools, but only 22, or 8 per cent reported that the budget was broken down into the subject matter areas. Money allocated for the purchase of science equipment, by the 121 schools which reported, ranged from $20 to $12,000, with the average amount being $1,013. Of this money, 111 schools reported actual expenditures ranging from $16 to $12,000, with the average amount being $1,032. When asked why not all of the money budgeted was spent, 27 of the schools, or 10 per cent, reported that it was because the teachers had failed to make requests for equipment and supplies.

The money budgeted for earth science was subdivided in the following way: Fifteen schools budgeted $25 or less for earth science equipment, eleven between $25 and $50, twenty-five between $50 and $100, seventy between $100 and $500, fourteen between $500 and $1,000, and nine budgeted over $1,000 for earth science equipment.

Of the 275 schools, 178 or 65 per cent of the principals indicated that their schools obtained National Defense Education Act matching funds for the purchase of equipment.

Within the group of schools sampled, the teaching of earth science began in 1955 when one of the schools reported offering this subject. Two schools followed in 1956, three more in 1957, five each year in 1958 and 1959, nineteen more in 1960, eleven in 1961, twenty-five in 1962, eighteen in 1963, six more in 1964, and sixteen in 1965. All of these schools offered courses in earth science before any textbooks were adopted by the State of Texas.

After the adoption of the three textbooks, fifty-five schools reported that they purchased Basic Earth Science, seventy-four schools reported they had purchased Earth Science: The World We Live In, and fifty schools reported that they had purchased Modern Earth Science. Twenty-nine schools reported that they had purchased textbooks other than these three. If they gave the name of the textbook, it almost always appeared to be a general science textbook.

Eighty-seven, or 32 per cent of the schools, reported that more than one of the three adopted textbooks would be available to the students for additional study. One hundred and eighty-two, or 66 per cent of the schools, reported that earth and space science books other than those adopted would be available to the students for additional study.

Of the 276 schools reporting, 5 reported earth science would be taught in the ninth-grade, 182 in the eighth-grade, 27 in the seventh-grade, 1 in the sixth-grade, and 61 did not report that they would teach earth science.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY AND CONCLUSIONS

Readability Determinations

The first part of this study was devoted to the determination of the readability of the state adopted, eighth-grade textbooks for earth science and general science. A new textbook that appeared to be suitable for eighth-grade earth science was also examined. The Dale-Chall formula was used to make the reading difficulty determinations.

Based upon Mallinson's recommendations that textbooks should have a reading difficulty of one grade lower than the grade in which they will be used, none of the textbooks examined appear to be suitable for use in eighth-grade classes.

Basic Earth Science has an average reading level of ninth-tenth-grade, as does *Earth Science: The World We Live In*. *Modern Earth Science* has an eleventh-twelfth-grade reading level.

The most difficult passage of *Basic Earth Science* is thirteenth-fifteenth-grade, while that of *Earth Science: The*

World We Live In is at the college level. It would, therefore, appear that Basic Earth Science would be the most suitable state adopted textbook even though its reading level would make it a difficult book for most of the eighth-grade students who would use it.

Exploring Earth Science has an average reading level of ninth-tenth-grade. Its most difficult passage has a reading level of thirteenth-fifteenth-grade. This book would appear to be just as suitable for eighth-grade use as is Basic Earth Science, and perhaps should also be adopted for use in the eighth-grade.

Modern Science and Science is Understanding are general science textbooks adopted for use in the eighth-grade. Modern Science has an average reading level of ninth-tenth-grade while Science is Understanding has a reading level of seventh-eighth-grade. Based upon reading level alone, it would appear that Science is Understanding is better suited for use in the eighth-grade. Even this book could present difficulties for the students with low reading abilities.

Teacher Preparation and Equipment Status of Texas Schools

If the 491 teachers who responded to the questionnaire are representative of the teachers of Texas, it is quite apparent that the Texas teachers are very poorly prepared to teach earth science. This would seem to be in agreement with the studies that have been made in the other states.

If the 275 schools, whose principals responded to the questionnaire, are representative of the schools of Texas, it would seem that the schools of Texas are not as well equipped as they might be. In the subjects which have been taught for several years, the equipment status, while not perfect, cannot be considered as extremely inadequate. Scientific equipment is expensive, and it is not likely that all schools could purchase all of the equipment they need within a short period of time.

Some instruments are produced primarily for use in one or more of the disciplines of earth science. For these things the picture is not as good as it is for the other scientific disciplines. The authors of the state adopted, earth science textbooks describe and make use of many different tools in their treatment of the subject. Somewhat less than half of the equipment described by these authors is owned by the schools. This lack of proper instruments will reduce the effectiveness with which the earth science subject matter can be presented.

The study did indicate that in most cases the equipment which is owned by the schools is readily available to the teacher for use in the classroom.

To summarize the situation, the textbooks are written at too high a reading level for students of the eighth-grade, and all but the best readers are likely to encounter difficulty with them. The teachers appear to be very poorly prepared to offer a course in earth science; only 4.5 per cent of those who replied to the questionnaire met the standards recommended by the Earth Science Curriculum Project. The equipment situation is somewhat better. Most of the schools from which questionnaires were returned had half or more of the equipment cited by the textbooks. It would, therefore, appear that if the new earth science course did not prove to be a success, the high reading level of the textbook, the low preparation level of the teachers, and inadequacy of equipment were factors in the results obtained. Blame for any unpopularity should not be placed entirely upon the subject matter of earth science.

RECOMMENDATIONS

Readability Determinations

As earth science becomes part of the curriculum of the public schools, new textbooks should be written for the junior high schools. Care should be exercised to keep the vocabulary used within the reading ability limits of the students who will be at the grade level for which the book is intended. Great care should be taken with the vocabulary load of these books in order that the subject matter is the material which challenges the student rather than the difficult vocabulary. Each discipline has its own technical language, and as much care should be used in the introduction of this new vocabulary as is used in building the basic vocabulary of the elementary school child.

Teacher Preparation and Equipment Status of Texas Schools

The shortage of well educated earth science teachers for the public schools is a national problem. Workers with the Earth Science Curriculum Project anticipate that more geology, or earth science, teachers will be needed in this nation than professional geologists.

Attention should, therefore, be given by departments of geology or earth science to the education of teachers to meet this great demand.

More attention should be given by superintendents of schools to the hiring of well qualified personnel to fill earth science openings. The superintendents should also have some knowledge of the content of the various courses taught within his school in order to better judge the qualifications of the applicants for positions.

Teaching certificate programs and the certifying of earth science teachers would be of great assistance in bringing to the schools properly qualified people for earth science teaching.

Many more summer programs should be started to upgrade those teachers who are now presenting earth science.

This is particularly true for the teachers who have had several years teaching experience, especially if they have not taken summer courses in an effort to keep up with the changes that are taking place within science and the teaching of science.

It has been said that there is no problem which more money will not solve. This is as true for the teaching profession as any other profession. Better salaries are very much needed to attract and hold teachers in all branches of science.

Advantage should be taken of both the federal and private foundation financing, which is now available, to create textbooks better suited to the junior high school students and the school grade for which they are intended. This money should be used to finance more summer institutes. These funds should also be used to properly equip the schools with the scientific and teaching supplies necessary for more effective teaching. All of this is essential if we are to meet the challenges and survive in today's highly scientific world.

APPENDIX A

NATIONAL CURRICULUM STUDIES

APPENDIX A

NATIONAL CURRICULUM PROJECTS

University of Illinois Curriculum Study in Mathematics

Experiments for this project were begun in 1961.

The University of Illinois Curriculum Study in Mathematics (UICSM) is a joint effort, under the direction of Dr. Max Beberman, by the College of Education, the College of Engineering, and the College of Liberal Arts and Sciences at the University of Illinois. The project is sponsored by the Carnegie Corporation of New York and the University of Illinois. At present UICSM has textbooks for grades 9, 10, and 11; texts for grade 12 will be available in 1962. The textbooks emphasize consistency, precision of language, structure of mathematics, and understanding of basic principles through pupil discovery. Discovery of generalizations by the student is a basic technique used throughout the course.

Work on the UICSM material began in 1952, and by the end of the 1959-60 school year the material had been used experimentally in 25 states by 200 teachers and 10,000 pupils. Participating teachers have received detailed instructions on the use of this experimental material from the Illinois Center.[1]

Ball State Teachers College Experimental Program

The Ball State Teachers College Experimental Program, initiated under the direction of Dr. Charles Brumfiel, is planned for pupils in grades 7 through 12. (Dr. Brumfiel, now at the University of Michigan, is still active in the project.) The program emphasizes the axiomatic structure of mathematics and precision of language. As a result of experimentation at the Ball State Laboratory School, Muncie, Indiana, materials for grades 8, 9, and 10 have gone through several revisions. The books, Introduction to Mathematics, Algebra I, and Geometry, are now being published by Addison-Wesley Publishing Company, Reading, Massachusetts. The texts are characterized by careful attention to logical development. Both algebra and geometry contain carefully constructed chapters on elementary logic. These chapters appear early in the texts, and the ideas developed in them are utilized continually in both courses.[1]

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[1] National Council of Teachers of Mathematics, The Revolution in School Mathematics, Kenneth E. Brown, "The Drive to Improve School Mathematics," A report of Regional Orientation Conferences in Mathematics (Washington: National Council of Teachers of Mathematics, 1961), p. 19.

Commission on Mathematics
College Entrance Examination Board

This study began in 1955.

In the spring of 1959 the Commission on Mathematics of the College Entrance Examination Board issued a 2-part report (Part I: Program for College Preparatory Mathematics; Part 2: Appendices) on the secondary mathematics curriculum for college-bound students. In this report the Commission recommends revision of the present high school mathematics program to emphasize deductive reasoning in algebra, structure of mathematics, unifying ideas, and treatment of inequalities, and to incorporate some coordinate geometry; a suggested sequence of topics for the high school curriculum is also included. The report may be obtained by writing the Commission on Mathematics, College Entrance Examination Board, c/o Educational Testing Service, Princeton, New Jersey.[2]

University of Maryland Mathematics Project

The project was begun in 1957.

The University of Maryland Mathematics Project (UMMaP), under the direction of Dr. John R. Mayor, was designed to develop an improved mathematics program for grades 7 and 8. Five mathematicians and approximately 40 teachers took part in planning and/or writing the experimental program, with consultative services from specialists in such other areas as psychology and testing.

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[1] Ibid., p. 20.

[2] Ibid., p. 20-21.

Although the original experiment was confined primarily to nearby schools (Prince Georges and Montgomery Counties, Maryland; Arlington County, Virginia; and the District of Columbia), the books have now been used in ten states by about 100 teachers with 5,000 pupils. The seventh grade textbook has been revised three times, and the eighth grade textbook, twice.

The courses are designed to serve as a bridge between arithmetic and high school mathematics. Unusual chapter title such as the following appear in the seventh grade textbook: "Systems of Numeration," "Symbols," "Properties of Natural Numbers," "Factoring and Primes," "The Numbers One and Zero," "Mathematical Systems," "Scientific Notation for Artihmetic Numbers," "Logic and Number Sentences."[1]

School Mathematics Study Group

This program was begun in 1958.

The School Mathematics Study Group (SMSG) represents the largest united effort for improvement in the history of mathematics education. It is national in scope. The director is Professor E. G. Begle, whose office was, until recently, at Yale University (probably the reason it is sometimes referred to as the Yale Project). In the fall of 1961 Professor Begle and SMSG headquarters moved to Standford University, Palo Alto, California. SMSG is financed by the National Science Foundation.

The development of the SMSG material is unique in that it represents the combined thinking of many people-psychologists, testmakers, mathematicians from colleges and industry, biologists, and high school teachers. Approximately 100 mathematicians and 100 high school teachers did the writing, and in order to produce material that is both mathematically sound and teachable, each writing team had an equal number from each group.

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[1] Ibid., p. 19.

During the school year 1959-60 sample textbooks and teachers' manuals for grades 7 through 12 were tried out in 45 states by more than 400 teachers and 42,000 pupils. During this tryout the teachers received guidance and consultative assistance from college mathematicians.

Throughout the year detailed evaluations of each chapter of the sample textbooks were submitted by teachers, mathematics advisers, and in some cases by the pupils themselves. All the suggestions and criticisms were studied and analyzed by the revision writing team composed of approximate 50 high school teachers and 50 mathematicians. The revision team made many changes--sharpening the discussion, giving better choice of graded exercises, and rewriting certain troublesome spots. They also rewrote those areas identified by the pupils as especially troublesome or difficult. Despite these revisions, it is significant that no changes were suggested in the basic mathematics or philosophy of the original material.

The SMSG textbooks contain new topics as well as changes in the organization and presentation of older topics. Attention is focused on important mathematical facts and skills and on basic principles that provide a logical framework for them.[1]

Greater Cleveland Mathematics Program

GCMP: Greater Cleveland Mathematics Program, also dating from 1958. The program offers math from kindergarten through grade 6 via worksheets and visual aids rather than texts, stressing how and why things happen in math rather than rule memorization.[2]

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[1] Ibid., p. 18.

[2] Terry Ferrer, Classroom Revolution, (Reprinted from the Hearld Tribune) (New York: New York Herald Tribune, Inc., 1963), p. not numbered, last page.

Madison Project

MP: Madison Project, operating out of Syracuse University since 1958. Largely dependent on classroom discussion and personal experiment ("go find the height of the school flagpole") the project "believes that we know almost nothing about how to teach mathematics to children" and hence we must start fresh.[1]

Geometry for Primary Grades

GPGP: Geometry for Primary Grades (including grade 1). Started in 1958, it was quickly followed by elementary texts in sets and numbers. Headquarters: Stanford University.[2]

Boston College Mathematics Institute

This program was begun in 1960.

The Boston College Mathematics Institute, under the supervision of Rev. Stanley J. Bezuszka, S.J., will eventually provide material for grades 8 through 12. An experimental textbook for grade 9 was completed, but it was found to be more suitable for grade 8. Another text for grade 9 is now being prepared.

Historical development is used to break away from the traditional approach as well as to give the pupil an opportunity to exercise his imagination and creativity and to encourage him to do some reading. Mathematics is studied through problems that confronted primitive man and questions currently being answered by mathematicians. The emphasis is on the structure of mathematics approached from the historical point of view.[3]

Developmental Project in Secondary Mathematics
Southern Illinois University

This program was begun in 1960.

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[1] Ibid.

[2] Ibid.

[3] Nation Council of Teachers of Mathematics, pp. 19-20.

The Developmental Project in Secondary Mathematics at Southern Illinois University, under the direction of Professors Morton R. Kenner and Dwain E. Small, receives financial assistance from the Marcell M. Holzer Fund for Education. This program emphasizes the structure of mathematics and precision of language. The language of sets and the axioms of mathematics stand out in the ninth grade textbook. The ninth and tenth grade materials have been tried out in the University High School. Materials for other secondary school grades are being developed.[1]

Physical Science Study Committee

PSSC: Physical Science Study Committee. Begun in 1956 at Massachusetts Institute of Technology, PSSC is now run by Educational Services Inc. in Watertown, Mass. The committee has completely revamped high-school physics and its laboratory work.[2]

The Physical Science Study Committee (PSSC) centers its new curriculum around the concept that matter and energy are conserved; space, time, matter cannot be separated. The idea of conservation of matter and energy helps us understand a world in which $E=mc^2$ is a reality. The sun's energy is found to come from a sustained fusion reaction; light, emitted by the sun, is both wave and corpuscle.[3]

Chemical Bond Approach Project

In 1957, a conference was set up at Reed College by the Committee on Teaching of the Division of Chemical Education and under the sponsorship of the Crown Zellerbach Foundation to review some of the more important problems in the better integration of the teaching of chemistry in high schools and colleges.

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[1] National Council of Teachers of Mathematics, p. 20.

[2] Terry Ferrer, p. last page.

[3] Paul F. Brandwein, "The Revolution in Science Education: An Examination of the New Secondary Science Curriculums," Teacher's Notebook in Science (New York: Harcourt, Brace and World, Spring, 1962), p. 6.

> Along with other matters, the Reed Conference expressed its dissatisfaction with high school texts in chemistry and its interest in the possibility of developing a new high school course based upon chemical bonding as a central theme. A committee of conference members led by L. E. Strong of Earlham and M. K. Wilson of Tufts developed a tentative outline of such a course. Among the recommendations of the conference was that a follow-up conference be held in 1958 to take a fresh look at the Reed outline and its implications and to review the experiences of the two high schools which made use of outlines in 1957-58.
>
> A proposal for such a conference was then submitted to the National Science Foundation by Wesleyan University with the support of the Committee on Institutes and Conferences of the Division of Chemical Education. This was approved and the conference was held in Middletown, Connecticut, on June 16-26, 1958.[1]

The Division of Chemical Education, mentioned in the above quotation, is a division of the American Chemical Society.

In 1959, the Chemical Bond Approach Committee established their headquarters at Earlham College, Richmond, Indiana. Their textbook is organized around a conceptual scheme which emphasizes that the properties of chemical substances can best be understood through the consideration of the bonds between the atoms that compose each structure.

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[1] M. Gilbert Burford and Harry F. Lewis, "The Wesleyan Conference of 1958: One Approach or Several?" Journal of Chemical Education, (XXXVI, February, 1959), p. 90.

Chemical Education Materials Study

In 1958, an Ad Hoc Committee was appointed by the American Chemical Society to study the possibility of revising the high school chemistry course. Dr. Alfred Garrett, Chairman of the Chemistry Department at Ohio State University, was named Chairman of the Committee. The Committee consisted of college professors of chemistry and a high school chemistry teacher. The Ad Hoc Committee, after deliberation, recommended that a revision be made of the high school chemistry course and suggested, in general, what the course should contain. Dr. Glenn T. Seaborg, Chancellor of the University of California, Berkeley California, was asked to be Chairman of the revision program. Doctor Seaborg, as Chairman of the program, named Dr. J. A. Campbell of Harvey Mudd College, Director of the Project. A Steering Committee was appointed which consisted of college professors, high school teachers and other specialists.

. . . .

The first meeting of the Steering Committee was held in January 1960 at the University of California in Berkeley.

. . . .

A writing conference was held in June and July, 1960 at Harvey Mudd College, Claremont, California. Nine college professors and nine high school teachers wrote the textual and laboratory materials. The first draft of a complete text was prepared and the first volume was rewritten and edited. One semester's laboratory experiments were written and tested.[1]

The Chemical Education Materials Study (CHEMS) is developing a curriculum around the concept that matter is particulate in nature. The chemist finds it helpful to think in terms of the conservation of atoms and of electrical charge, not so much directly in terms of conservation of mass and energy.[2]

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[1] R. L. Silber, "The Chemical Education Materials Study Approach to Introductory Chemistry," School Science and Mathematics, (LXI, February, 1961),pp. 114-115.

[2] Paul F. Brandwein, p. 7.

Biological Sciences Curriculum Study

The BSCS program eas established by the American Institute of Bilogical Sciences in 1959. It is housed at the University of Colorado, Boulder, Colorado.

> The Biological Sciences Curriculum Study (BSCS) organized three curriculums. All three have the unifying threads of a society of ideas: diversity of the type of living things amidst unity in pattern; genetic continuity of life; interdependence of organisms and environment; interdependence of structure and function; regulation and homeostasis; biological roots of behavior. However, the emphasis is different in each version; in each, the biological world is examined from a different vantage point. The curriculum called the Blue Version emphasizes the molecular level of biology; the Yellow Version explores the cellular level; the Green Version centers on the biome and the community.[1]

Earth Science Curriculum Project.

The Earth Science Curriculum Project is discussed in detail in various parts of the preceding text.

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[1] Paul F. Brandwein, p. 6.

APPENDIX B

QUESTIONNAIRE USED TO SURVEY TEXAS TEACHERS AND SCHOOLS

EAST TEXAS STATE COLLEGE
EAST TEXAS STATION
COMMERCE, TEXAS

DEPARTMENT OF EARTH SCIENCES

ASTRONOMY
GEOLOGY
METEOROLOGY
OCEANOGRAPHY
PALEONTOLOGY

March 22, 1965

Dear Sir:

As you know, the State of Texas has recently adopted three earth and space science textbooks for use in eighth grade classes. It would appear that earth and space science has now become an accepted part of our junior high school curriculum.

For the last several years East Texas State College has offered three programs leading to either an elementary or secondary teaching certificate with an emphasis on earth and space science. East Texas State College is at present the only college in the state with such a complete program in earth and space science for teachers. We are therefore interested in obtaining certain information from the principals of selected Texas schools. Specifically, we would like to know how well you feel your teachers are prepared, and how well your school is equipped, to present this new material.

We would like to send a representative to your campus to meet and interview you in order that we can improve our service to you. However, a lack of time and money prevents our using such a program, and we regretfully are forced to use a questionnaire. We certainly would appreciate your taking the time to complete the attached form. If you fold the questionnaire in the same way in which it was folded to fit into the envelope and staple it together so that all of the pages are secured, the return postage will be paid.

The first page, and in some cases the first two or three, are perforated so that part of the page can be given to each teacher who will teach earth and space science in order that he or she can indicate his or her academic preparation. They can do this by filling in the number of courses they have completed in the areas requested. These small slips can then be folded into and stapled into the questionnaire when it is folded and stapled for mailing.

The last two pages can be completed by either a number or a check (✓) mark. A check mark means Yes, and a blank space means No. We designed this form to reduce completion time to a minimum.

We plan to use the information developed to modify, if necessary, our program for the 1965 - 1966 school year. In order that we can do this, we would appreciate your returning this questionnaire by May 15, 1965, at the latest. In the event that you are unable to complete the entire form, please return what you can complete to us, crossing out the items that you can not answer. If you can not complete any part of it, and can not pass it on to someone who can, please return the blank questionnaire to us. We are asking you to do this to spare you the bother of having to handle follow-up questionnaires.

When the questionnaire is completed, fold all of the small pages into the large ones and then the large ones like they were folded into the envelope. Then, please staple the pages together so that none can fall out. The return address and postage permit should now be on the outside. We will pay the return postage.

If you have any comments or suggestions, you can write them on the back of the next to the last page. Blank spaces are also provided for additional information. For your convenience, a check mark means YES, a blank space means NO.

We regret that we could not meet you and talk to you personally. We hope that you will complete and return the questionnaire.

Thank you for your kindness in doing so.

Yours very truly,
Department of Earth Sciences

Loren E. Kline, Jr.
Loren E. Kline, Jr.

Please have each teacher who will teach a course in earth and space science complete one of the following blanks. Please have the teacher indicate the number of courses he or she has had in the following sciences. Also, please have the teacher indicate with a check mark the degrees he or she holds. It is not necessary that the person be identified. The individual teachers' questionnaires may be separated in order that one can be given to each teacher teaching earth and space science. Blank spaces are available for any items you might wish to add.

Please indicate in the blanks the number of courses you have had in the following sciences. Also, please indicate the degrees you hold by a check mark in the blanks. Blank spaces are available for any items you might wish to add.

1. Agriculture		2. Astronomy		3. Bachelor Degree	
4. Biology		5. Geology		6. Master Degree	
7. Chemistry		8. Meteorology		9.	
10. Engineering		11. Mineralogy		12. Home Economics	
13. Forestry		14. Oceanography		15.	
16. Mathematics		17. Paleontology		18.	
19. Physics		20. Total of all Earth Science Courses taken			
21. How many earth science courses do you teach each day?					

Please indicate in the blanks the number of courses you have had in the following sciences. Also, please indicate the degrees you hold by a check mark in the blanks. Blank spaces are available for any items you might wish to add.

1. Agriculture		2. Astronomy		3. Bachelor Degree	
4. Biology		5. Geology		6. Master Degree	
7. Chemistry		8. Meteorology		9.	
10. Engineering		11. Mineralogy		12. Home Economics	
13. Forestry		14. Oceanography		15.	
16. Mathematics		17. Paleontology		18.	
19. Physics		20. Total of all Earth Science Courses taken			
21. How many earth science courses do you teach each day?					

Please indicate in the blanks the number of courses you have had in the following sciences. Also, please indicate the degrees you hold by a check mark in the blanks. Blank spaces are available for any items you might wish to add.

1. Agriculture		2. Astronomy		3. Bachelor Degree	
4. Biology		5. Geology		6. Master Degree	
7. Chemistry		8. Meteorology		9.	
10. Engineering		11. Mineralogy		12. Home Economics	
13. Forestry		14. Oceanography		15.	
16. Mathematics		17. Paleontology		18.	
19. Physics		20. Total of all Earth Science Courses taken			
21. How many earth science courses do you teach each day?					

Please indicate in the blanks the number of courses you have had in the following sciences. Also, please indicate the degrees you hold by a check mark in the blanks. Blank spaces are available for any items you might wish to add.

1. Agriculture		2. Astronomy		3. Bachelor Degree	
4. Biology		5. Geology		6. Master Degree	
7. Chemistry		8. Meteorology		9.	
10. Engineering		11. Mineralogy		12. Home Economics	
13. Forestry		14. Oceanography		15.	
16. Mathematics		17. Paleontology		18.	
19. Physics		20. Total of all Earth Science Courses taken			
21. How many earth science courses do you teach each day?					

For questions requiring a yes or no answer, a check (✓) mark means YES, a blank means NO.

1. At what grade level will a formal course in earth and space science be taught?	
2. Please indicate the number of classes of earth and space science that you expect to offer.	
3. Please give the number of teachers that you expect to have teaching these courses.	

Please indicate the units into which the course will be broken by giving the number of weeks that will be spent on each unit.

4. Astronomy		5. Space Travel	
6. Oceanography		7. Meteorology	
8. Geology		9. Map Study	
10. Rocks and Minerals		11. Historical Geology and Paleontology	
12.		13.	

Which textbook will you use?

14. Basic Earth Science by MacCracken, Decker, Read, and Yarian	
15. Earth Science by Namowitz and Stone	
16. Modern Earth Science by Ramsey and Burckley	
17.	

18. Will more than one of the adopted textbooks be available to the student for additional study?	
19. Will earth and space science books, other than the adopted ones, be available to the student for additional study?	
20. Is the equipment stored in the classroom of the teacher who will use it?	
21. Is the equipment stored in a central place?	
22. Is the equipment stored in a laboratory?	
23. Is the equipment stored in a different building rather than in the one in which earth and space science will be taught?	
24. If the equipment is not stored in the classroom, is there a formal procedure for obtaining the equipment when it is needed?	
25. Do you feel that the above procedure provides for the maximum use of the equipment?	
26. Do you feel that the above procedure provides adequate use of the equipment?	
27. Do you feel that the above procedure limits the use of equipment?	
28. Do you feel that the above procedure discourages the use of equipment?	
29. When equipment is purchased for the course in earth and space science, is the teacher who will use this material consulted concerning the type and brand of equipment that will be purchased?	
30. When equipment is being purchased, can the teacher get the type and brand of equipment that he or she desires?	
31. Does the school have a specific budget item for the purchase of science equipment?	
32. Is this budget specifically broken down into subject matter areas, such as for earth and space science equipment?	
33. How much money was allocated for the purchase of science equipment during the 1963 - 1964 school year?	
34. How much of this money was actually spent?	
35. If not all of the budget was spent, was this because the teachers failed to make requests for equipment and supplies?	

Please check the approximate amount of money specifically budgeted for the course in earth and space science.

36. $0 - $25		37. $25 - $50		38. $50 - $100	
39. $100 - $500		40. $500 - $1000		41. $1000 or more	

42. Does your school obtain equipment through the use of the National Defense Education Act matching funds?	
43. If this is not the first year that a course in earth and space science has been offered in your school, could you give the approximate year when such a course was first offered?	

Please indicate with a check (✓) mark, in the blank space following the item, those supplies which are available for classroom use. The item, such as dry ice, need not always be on hand, but if you have access to it, please indicate its availability with a check mark. If you can not get the item for classroom use, please leave the space blank. If you wish to add items, blank spaces have been provided for this purpose.

1. Bunsen Burners		2. Ring Stands		3. Ring Stand Clamps	
4. Glass Dishes		5. Glass Plates		6. Glass Bottles	
7. Squeeze Bottles		8. Wide Mouth Jars		9. Glass Jars	
10. Rubber Stoppers		11. Trays		12. Glass Tubing	
13. Triangular Files		14. Rubber Tubing		15. Hose Clamps	
16. Magnetic Compass		17. Bar Magnets		18. Horseshoe Magnets	
19. Magnifying Glasses		20. Lenses		21. Binoculars	
22. Triangular Prisms		23. Microscope		24. Microscope Slides	
25. Canada Balsam		26. Cover Glasses		27. Tongs	
28. Toy Gyroscope		29. Hot Plate		30. Electric Fan	
31. Extension Cords		32. Step Ladder		33. Dry Ice	
34. Wooden Blocks		35. Hammer		36. Mailing Tubes	
37. Charcoal Blocks		38. Sky Charts		39. Globe	
40. Geographic Maps		41. Topographic Maps		42. Weather Maps	
43. Barometer		44. Rain Guage		45.	

46. Beakers, assorted sizes		47. Flasks, assorted sizes and kinds	
48. Graduated Cylinders		49. Test Tubes, assorted sizes	
50. Rectangular Acquarium or Tank		51. Record Player or Turntable	
52. Scale, Beam Balance		53. Weights for Beam Balance Scale	
54. Scale, Spring Balance		55. Pans, assorted sizes	
56. Thermometer, Fahrenheit		57. Thermometer, Centigrade	
58. Thermometer, Celsius		59. Sling Psychrometer	
60. Atomic Models		1. Models of the Universe	

2. Hydrochloric Acid		3. Copper Wire		4. Copper Sulphate	
5. Iron Rods		6. Iron Wire		7. Iron Filings	
8. Silver Iodide		9.		10.	
11. Mineral Collection		12.		13.	
14. Sand		15. Sandstone		16. Shale	
17. Limestone		18. Salt		19. Flint	
20. Agate		21. Chalcedony		22. Quartz	
23. Milky Quartz		24. Red Iron Ore		25. Yellow Iron Ore	
26. Bauxite		27. Gypsum		28. Sulphur	
29. Marble		30. Talc		31. Mica	
32. Microcline		33. Granite		34. Hornblende	
35. Basalt		36. Obsidian		37. Asbestos	
38. Fluorite		39. Hematite		40. Lodestone	
41. Pyrite		42. Copper Ore		43. Galena	
44. Fossil Collection		45.		46. Shell Collection	
47. Trilobites		48. Brachiopods		49. Crinoids	
50. Coral		51. Pelecypods		52. Oysters	
53. Leaf Impressions		54. Fossil Wood		55. Models of Dinosaurs	

Please indicate with a check (✓) mark the approximate amount of the above material that was purchased specifically for a course in earth and space science.

56. 0% - 25% ____ 57. 25% - 50% ____ 58. 50% - 75% ____ 59. 75% - 100% ____

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VITA

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Loren E. Kline, Jr., son of Loren E. Kline and Edith Hahne Kline, was born on February 16, 1917, in Philadelphia, Pennsylvania. He attended the public schools of Philadelphia, and graduated from Overbrook High School in February, 1935.

After graduating from The Pennsylvania State University, in June, 1940, with a Bachelor of Science degree in Geology, he went to work for the New Jersey Zinc Company. He worked as a geologist and mining engineer in New Jersey, Pennsylvania, and Virginia from 1940 through 1945.

On June 3, 1945, he married Eleanor H. Beidelman, daughter of William H. Beidelman and Florence Ebert Beidelman, of Spring Valley, Pennsylvania.

He worked from 1946 through 1952 as a paleontologist and exploration geologist for the Humble Oil and Refining Company in Texas and Mississippi.

A son, Loren William Kline, was born on July 18, 1946, in Bethlehem, Pennsylvania.

During the Spring Quarter of 1951, Loren Kline was a Special Lecturer at the University of Southern Mississippi.

From 1953 until the spring of 1955, he was District Geologist of the San Antonio District of the Pure Oil Company.

A daughter, Martha Louise Kline, was born on January 5, 1954, in San Antonio, Texas.

In the spring of 1955, he set up the firm of Loren E. Kline, Jr., Consulting Geologist and Mining Engineer, specializing in the exploration for uranium. Among his clients were the Dow Chemical Company, Southern Minerals Corporation, and the Pittsburgh Plate Glass Company. This firm was active from 1955 through 1960.

During the three academic years from 1958 until 1961, he taught mathematics at William Adams High School in Alice, Texas.

During the 1961-62 academic year, he was a student and Assistant Instructor at the Texas College of Arts and Industries. He graduated with a Master of Science degree in August, 1962, with majors in Education and Psychology.

During the 1962-63 academic year, he taught science and mathematics at Dubose Junior High School in Alice, Texas.

During the three academic years from 1963 until 1966, he served as a Doctoral Fellow and Assistant Instructor while he completed his work on the Doctor of Philosophy degree.

Loren Kline is a member of the following honorary and professional organizations:

American Institute of Mining, Metallurgical, and Petroleum Engineers
American Association of Petroleum Geologists
American Association for the Advancement of Science
American Personnel and Guidance Association

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Because of his work in uranium geology, his biographical sketch appears in

Who's Who in the South and Southwest
Who's Who in Commerce and Industry.

This dissertation was typed by Lillian D. Logue.